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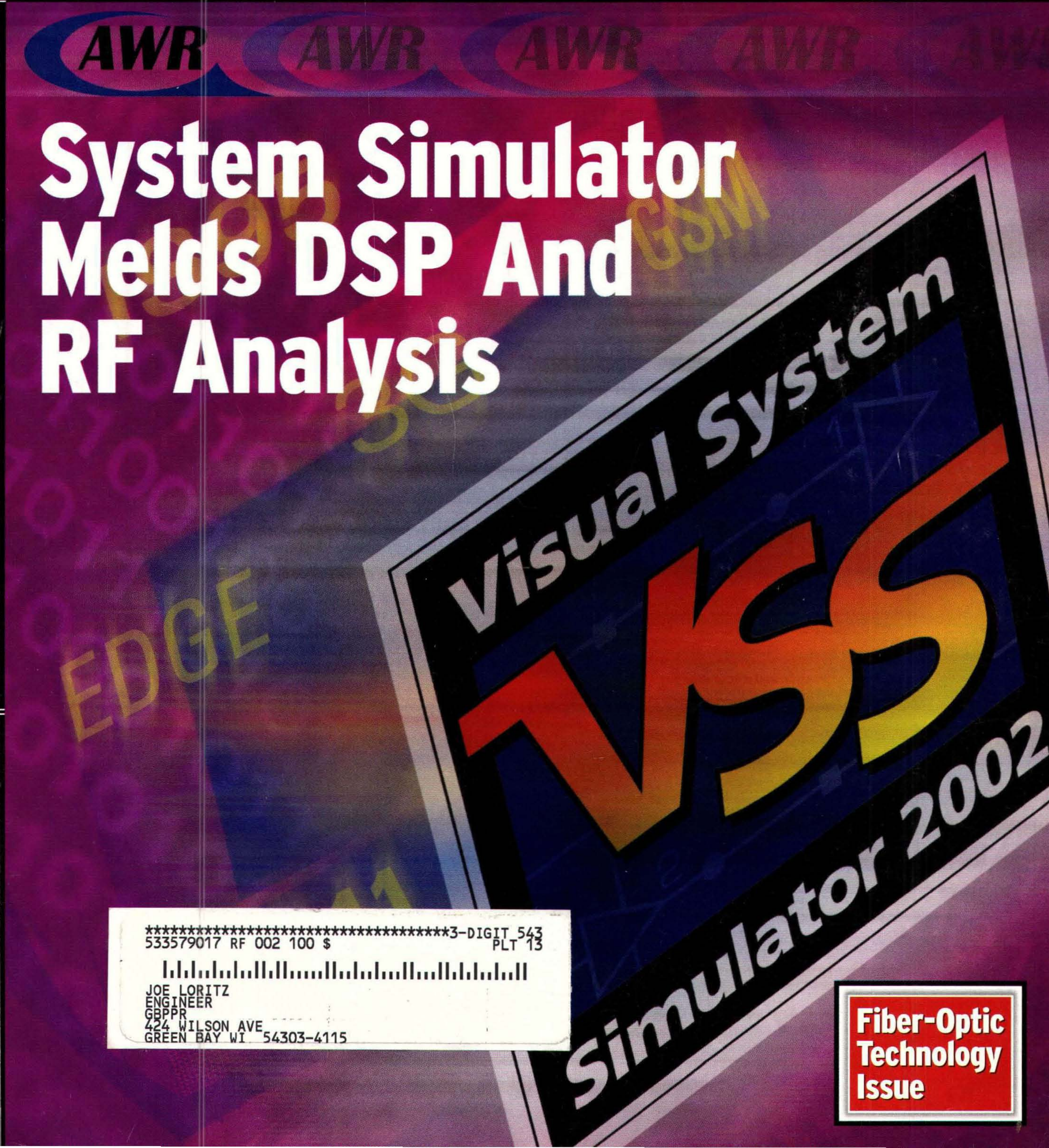
News
Update on optical communications

Design Feature
Design circuits for short-range radios

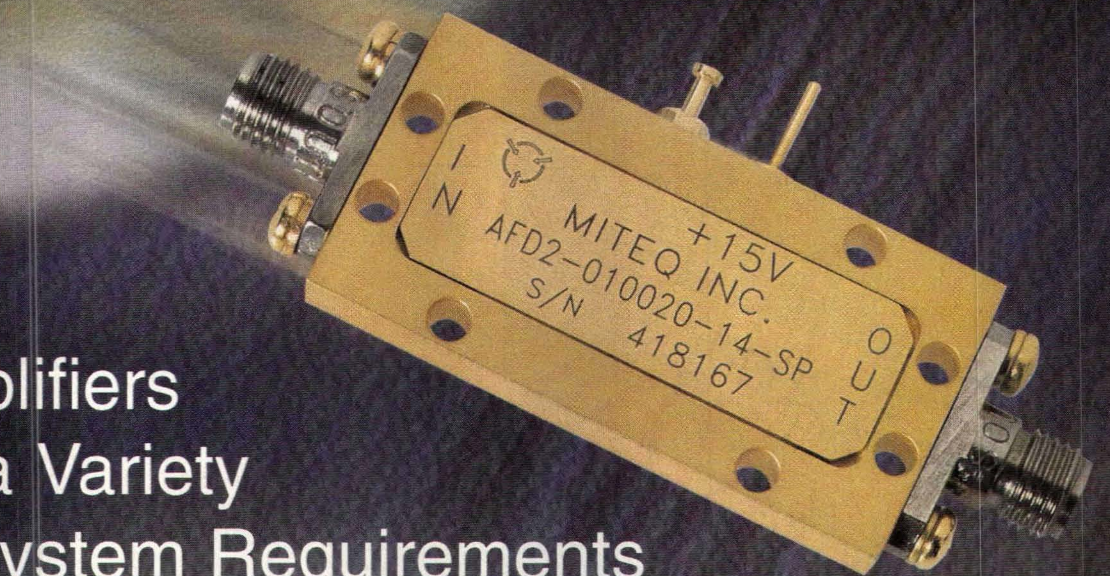
Product Technology
System automates reliability testing

System Simulator Melds DSP And RF Analysis



Fiber-Optic Technology Issue

Moderate & Octave Band Amplifiers



Amplifiers for a Variety of System Requirements

MODEL NUMBER	FREQ. (GHz)	GAIN (dB, Min.)	GAIN FLATNESS (±dB, Max.)	NOISE FIGURE (dB, Max.)	IN/OUT VSWR	POWER OUT (dBm, Min.)	CURRENT (mA, Typ.)
AFD2-010020-14-SP	1–2	20	1.50	1.4	2.0:1	+10	100
AFD3-010020-14-SP	1–2	34	1.25	1.4	2.0:1	+10	120
AFD3-022023-12-SP	2.2–2.3	30	0.50	1.2	1.5:1	+10	100
AFD3-023027-12-SP	2.3–2.7	30	0.50	1.2	1.5:1	+10	100
AFD3-027031-12-SP	2.7–3.1	30	0.50	1.2	1.5:1	+10	100
AFD3-031035-12-SP	3.1–3.5	30	0.50	1.2	1.5:1	+10	100
AFD3-037042-12-SP	3.7–4.2	30	0.50	1.2	1.5:1	+10	100
AFD3-040080-35-SP	4–8	24	1.25	3.5	2.0:1	+10	150
AFD3-020080-40-SP	2–8	23	1.50	4.0	2.0:1	+10	150
AFD3-040120-55-SP	4–12	18	1.50	5.5	2.0:1	+10	150
AFD3-080120-50-SP	8–12	18	1.25	5.0	2.0:1	+10	150
AFD1-010020-23P-SP	1–2	11	1.00	4.0	2.0:1	+23	275
AFD2-010020-23P-SP	1–2	25	1.50	3.5	2.0:1	+23	400
AFD3-020027-23P-SP	2.0–2.7	22	1.25	4.5	2.0:1	+23	350
AFD3-027031-23P-SP	2.7–3.1	22	1.25	4.5	2.0:1	+23	350
AFD3-031042-23P-SP	3.1–4.2	22	1.25	4.5	2.0:1	+23	350
AFD3-040080-23P-SP	4–8	20	1.25	5.5	2.0:1	+23	350
AFD3-020080-20P-SP	2–8	18	1.50	6.0	2.0:1	+20	350
AFD3-080120-20P-SP	8–12	15	1.50	6.5	2.0:1	+20	350
AFD3-040120-18P-SP	4–12	15	1.75	6.5	2.0:1	+18	350

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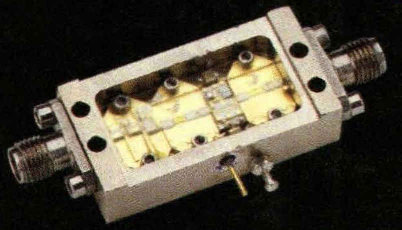

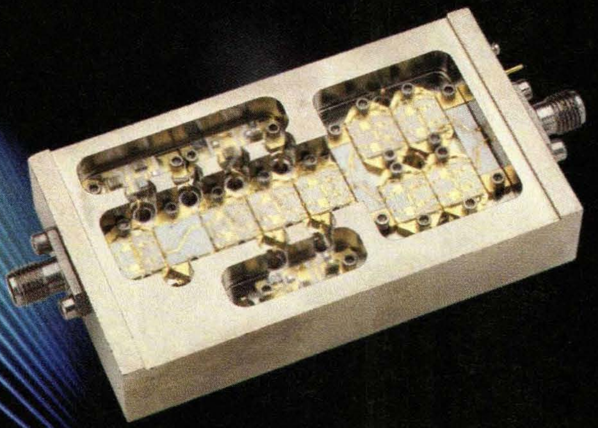

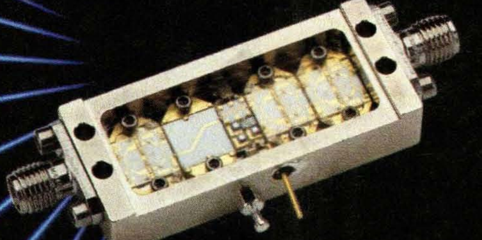

ULTRA BROAD BAND

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA018-203	0.5-18.0	20	5.0	2.5	7	17	2.0:1	250
JCA018-204	0.5-18.0	25	4.0	2.5	10	20	2.0:1	300
JCA218-506	2.0-18.0	35	5.0	2.5	15	25	2.0:1	400
JCA218-507	2.0-18.0	35	5.0	2.5	18	28	2.0:1	450
JCA218-407	2.0-18.0	30	5.0	2.5	21	31	2.0:1	500

MULTI OCTAVE AMPLIFIERS

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA04-403	0.5-4.0	27	5.0	1.5	17	27	2.0:1	550
JCA08-417	0.5-8.0	32	4.5	1.5	17	27	2.0:1	550
JCA28-305	2.0-8.0	22	5.0	1.0	20	30	2.0:1	550
JCA212-603	2.0-12.0	32	5.0	3.0	14	24	2.0:1	550
JCA618-406	6.0-18.0	20	6.0	2.0	25	35	2.0:1	600
JCA618-507	6.0-18.0	25	6.0	2.0	27	37	2.0:1	800

MEDIUM POWER AMPLIFIERS

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-P01	1.35-1.85	35	4.0	1.0	33	41	2.0:1	1000
JCA34-P02	3.1-3.5	40	4.5	1.0	37	45	2.0:1	2200
JCA56-P01	5.9-6.4	30	5.0	1.0	34	42	2.0:1	1200
JCA812-P03	8.0-12.0	40	5.0	1.5	33	40	2.0:1	1700
JCA1218-P02	12.0-18.0	22	4.0	2.0	25	35	2.0:1	700

LOW NOISE OCTAVE BAND LNA'S

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-3001	1.0-2.0	40	0.8	1.0	10	20	2.0:1	200
JCA24-3001	2.0-4.0	32	1.2	1.0	10	20	2.0:1	200
JCA48-3001	4.0-8.0	40	1.3	1.0	10	20	2.0:1	200
JCA812-3001	8.0-12.0	32	1.8	1.0	10	20	2.0:1	200
JCA1218-800	12.0-18.0	45	2.0	1.0	10	20	2.0:1	250

NARROW BAND LNA'S

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-1000	1.2-1.6	25	0.75	0.5	10	20	2.0:1	80
JCA23-302	2.2-2.3	30	0.8	0.5	10	20	2.0:1	80
JCA34-301	3.7-4.2	30	1.0	0.5	10	20	2.0:1	90
JCA56-401	5.4-5.9	40	1.0	0.5	10	20	2.0:1	120
JCA78-300	7.25-7.75	27	1.2	0.5	13	23	2.0:1	120
JCA910-3000	9.0-9.5	25	1.2	0.5	13	23	1.5:1	150
JCA910-3001	9.5-10.0	25	1.2	0.5	13	23	1.5:1	150
JCA1112-3000	11.7-12.2	27	1.1	0.5	13	23	1.5:1	150
JCA1213-3001	12.2-12.7	25	1.1	0.5	10	20	2.0:1	200
JCA1415-3001	14.4-15.4	35	1.4	1.0	14	24	2.0:1	200
JCA1819-3001	18.1-18.6	25	1.8	0.5	10	20	2.0:1	200
JCA2021-3001	20.2-21.2	25	2.0	0.5	10	20	2.0:1	200

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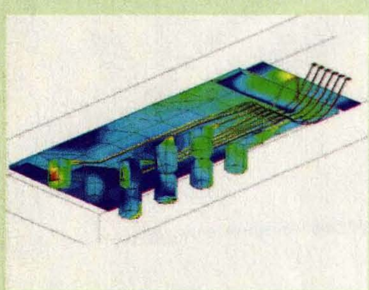
Important Announcements:

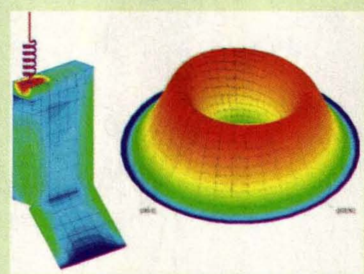
- The IE3D Release 7 has robust and efficient advanced symbolic electromagnetic optimization.
- The FIDELITY Release 3 has complete SAR analysis features for the wireless applications.
- The IE3D with precise modeling of enclosure will be added soon. The IE3D has been known for its open structure formulation and its flexibility and capability in modeling 3D and planar structures of general shape. The implementation of enclosure will make the IE3D more flexible in the modeling of microwave circuits and antennas. Microwave designers will no longer be locked to a uniform grid for enclosed structures.

IE3D Simulation Examples and Display

The current distribution on an AMKOR SuperBGA model at 1GHz created by the IE3D simulator

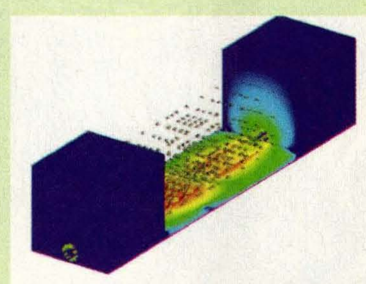


The current distribution and radiation pattern of a handset antenna modeled on IE3D

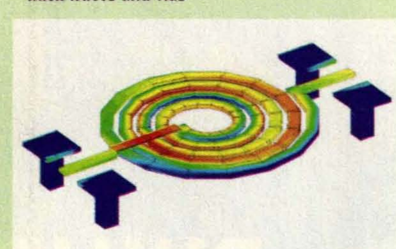


FIDELITY Examples

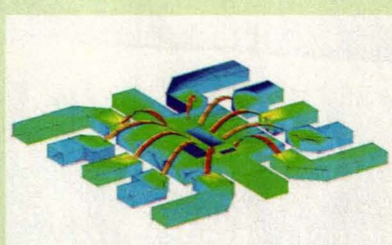
The near field and Poynting vector display on a packaged PCB structure with vias and connectors



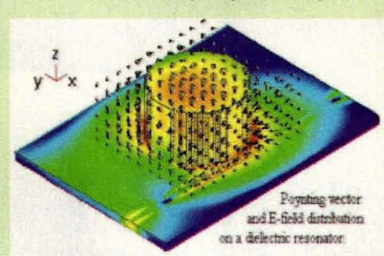
IE3D modeling of a circular spiral inductor with thick traces and vias



IE3D modeling of an IC Packaging with Leads and Wire Bonds



FIDELITY modeling of a cylindrical dielectric resonator and the Poynting vector display



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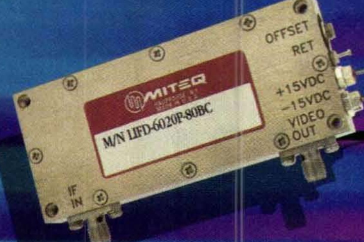
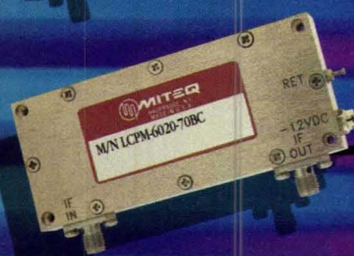


MODEL NUMBER	CENTER FREQUENCY (MHz)	DYNAMIC RANGE (dBm, Min.)	LINEARITY (dB, Max.)	RISE TIME (ns, Max.)	LOGGING SLOPE INTO 93 OHMS (mV/dB, Typ.)
LIFD-3010P-80BC	30	-80 to 0	±0.5	100	25
LIFD-6020P-80BC	60	-80 to 0	±0.5	50	25
LIFD-7030P-80BC	70	-80 to 0	±0.5	30	25
LIFD-16040-80BC	160	-80 to 0	±1.0	30	25
LIFD-300100-70BC	300	-70 to 0	±1.0	20	15

CONSTANT PHASE LIMITING AMPLIFIERS

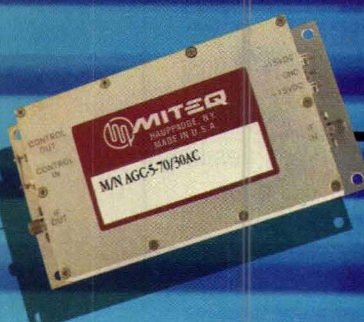


MODEL NUMBER	CENTER FREQUENCY (MHz)	DYNAMIC RANGE (dB, Min.)	OUTPUT POWER (dBm, Min.)	POWER VARIATION (dB, Max.)	PHASE VARIATION (Max.)
LCPM-3010-70BC	30	-70 to 0	10	±0.5	±3°
LCPM-6020-70BC	60	-70 to 0	10	±0.5	±3°
LCPM-7030-70AC	70	-65 to 5	10	±0.5	±5°
LCPM-16040-70BC	160	-65 to 5	10	±1.0	±3°

FREQUENCY DISCRIMINATORS

MODEL NUMBER	CENTER FREQUENCY (MHz)	LINEAR BANDWIDTH (MHz, Min.)	SENSITIVITY (mV/MHz, Typ.)	LINEARITY (%, Max.)	RISE TIME (ns, Max.)
FMDM-30/6-3BC	30	6	1000	±3	120
FMDM-60/16-4BC	60	16	250	±3	90
FMDM-70/36-10AC	70	36	50	±2	50
FMDM-160/35-15BC	160	35	100	±2	30
FMDM-160/50-15AC	160	50	40	±2	25
FMDM-750/150-20BC	750	150	20	±3	20
FMDM-1000/300-50AC	1000	300	10	±5	7

AUTOMATIC GAIN CONTROL LINEAR AMPLIFIERS



MODEL NUMBER	CENTER FREQUENCY (MHz)	BANDWIDTH (-3 dB) (MHz, Min.)	DYNAMIC RANGE (dBm, Min.)	OUTPUT POWER (dBm, Min.)	POWER VARIATION (dB, Max.)
AGC-7-10.7/4AC	10.7	4	-70 to 0	10	±0.5
AGC-7-21.4/10AC	21.4	10	-70 to 0	10	±0.5
AGC-5-70/30AC	70	30	-50 to 0	-4	±0.5
AGC-7-160/30AC	160	30	-70 to 0	8	±1.5
AGC-7-300/400AC	300	400	-65 to 0	3	±1.0

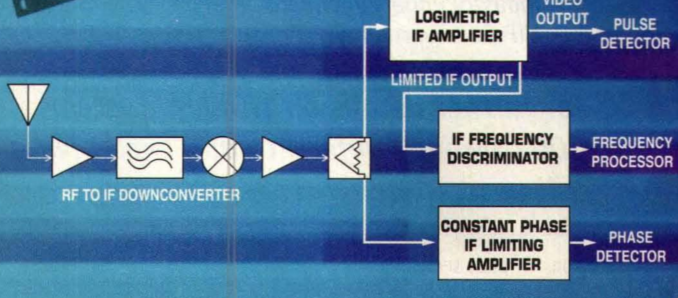


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Figure Clarity

▶▶I NOTICED THERE were a couple of errors that appeared in Fig. 1 of the article "Reviewing The Basics Of MMIC Design" which appeared on page 55 in the June 2001 issue.

The reactance of the Ls and Cs should be 70.7 Ω. Therefore, the C/2 in the "PI" module should be C and the L/2 in the "T" model should be L. The Wilkinson Coupler's input capacitor should be 2C and the C/2 should be C. Lastly, the lengths of the 70.7-Ω transmission line should be a quarter wave and not a half.

Tom Cefalo
Sigtech

Correct Equations

▶▶I WOULD LIKE to thank you for publishing my article "Interpret And Apply EVM To RF System Design" that appeared in your December 2001 issue (pp. 83-94). I did, however, find some typos that need to be corrected. On page 84, Eqs. 4 and 5 are printed incorrectly. They should read:

$$EVM_k = \left\{ |E_k|^2 / \left[\left(\Sigma |S_k|^2 \right) / K \right] \right\}^{0.5} \quad (4)$$

$$RMS\ EVM = \left[\left(\Sigma |E_k|^2 \right) / \left(\Sigma |S_k|^2 \right) \right]^{0.5} \quad (5)$$

Aaron Netsell
RF Design Engineer
Motorola GTSS
Arlington Heights, IL

Incorrect Statements

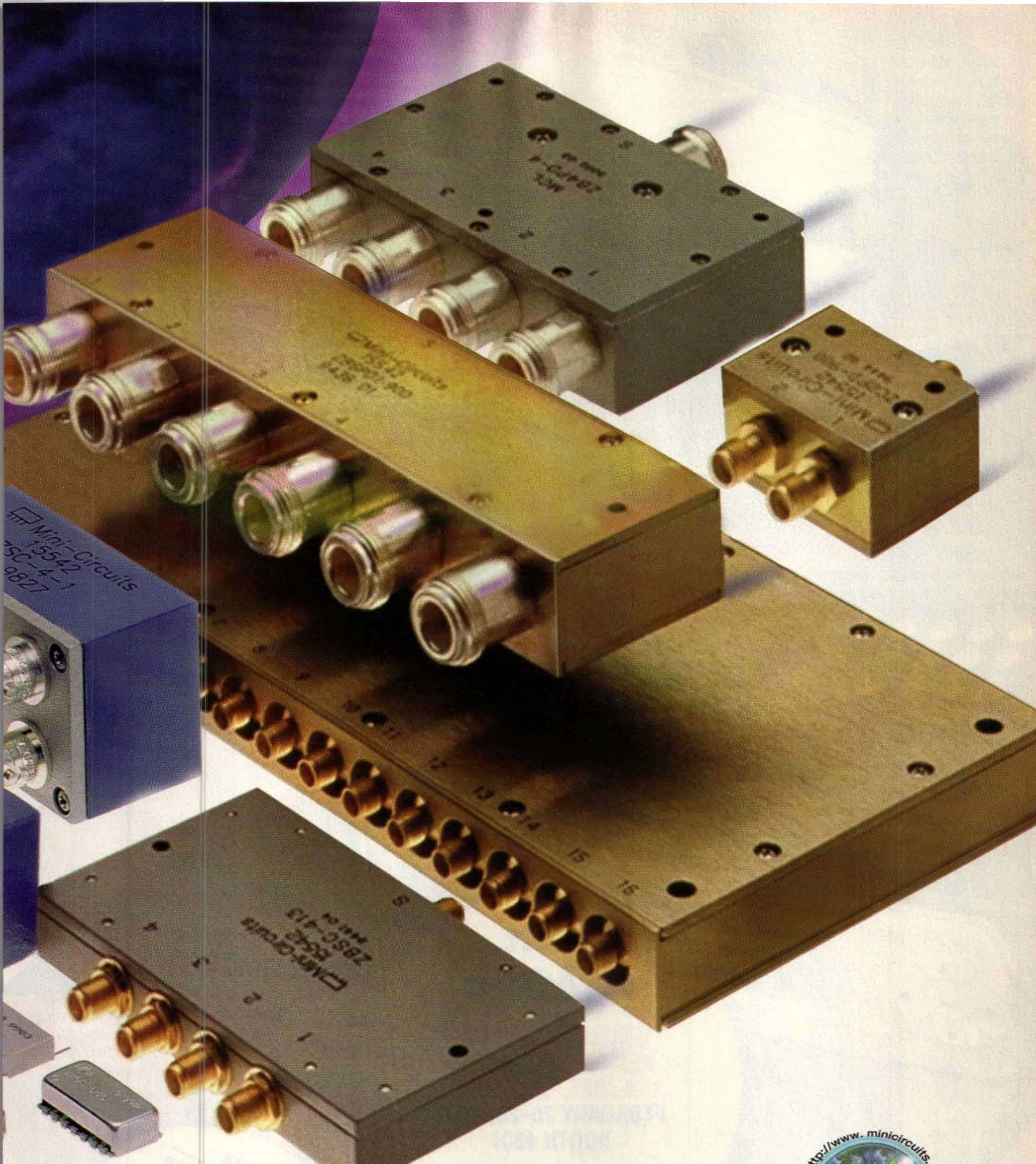
▶▶IN THE ARTICLE "Practical Guidelines Target LNA Design," which appears in the October 2001 issue of *Microwaves & RF* (p. 106), the author, Alphonse Harter, makes some incorrect statements.

He says, "If Z_L differs from Z_0, some of the incident wave is not absorbed in the load, but is reflected back toward the source." This is not necessarily the case.

Suppose the transmission line is a quarter-wave impedance transformer. It is possible to match two unequal impedances this way, without Z_0 being equal to Z_L. The impedance of the required quarter-wave section of transmission line will be the square root of $Z_s * Z_L$.

The next statement on page 106 says, "If the source impedance Z_s equals Z_0, the reflected wave from the load is absorbed in the source and no further reflection occurs." This is not true.

Editor's Note: Due to the length of this letter, it will be continued in next month's (March) Feedback and will appear as the first one.


Mini-Circuits
15542

Waiting For The Wireless Revival

Wireless technology was the salvation of an entire industry during the 1990s. High-frequency companies quickly shifted their attention in the early 1990s from military customers to emerging commercial communications customers, especially in cellular-communications markets, eager to be a part of the "wireless revolution." For almost a decade, designing and manufacturing anything for the wireless market—be it a tiny IC or a tower on which to mount an antenna—was enough to ensure a successful business.

But all through human history, the turn of the millennium has been anticipated with dread or, more precisely, with the fear of the unknown. Although there is no scientific reason that a change of calendars would bring an end to business prosperity, the current economic decline in electronics (and in just about every other field) can be traced to the beginning of the new millennium (which, technically, began in 2001).

There is no one way or one simple answer for the revival of wireless business. But new products and new ideas have always been effective ways to spark business growth.

Downturn might be too mild a word to describe the state of wireless business during 2001. For companies such as Lucent Technologies and Motorola, catastrophic might be more fitting. These are "communications" companies (among many others) that have had to endure massive layoffs in personnel during the last year just to try to balance their business ledgers. In researching information for the Special Report on optical communications beginning on p. 33, it became apparent that even communications companies outside of the wireless sphere, such as Corning and JDS Uniphase, were hard hit in 2001.

There is no one way or one simple answer for the revival of wireless business. But new products and new ideas have always been effective ways to spark business growth. When the wireless "industry" was still in its formative stages, the fledgling Wireless Symposium & Exhibition served as a meeting place and a launching pad for new ideas and new products. It is 10 years later, and the industry and the show have changed (it is now known as Wireless Systems 2002), but the main thrust of the show is the same—to provide a meeting place to exchange design ideas and to explore the potential of emerging technologies. For a large segment of the wireless design community, the show is still accessible without taking a flight (in the San Jose Convention Center from February 25-28, 2002), and is still a wonderful opportunity to make new connections. Hopefully, in its 10th Anniversary, the show can trigger a revival in high-frequency business to rival the growth that came after that first show.

Jack Browne

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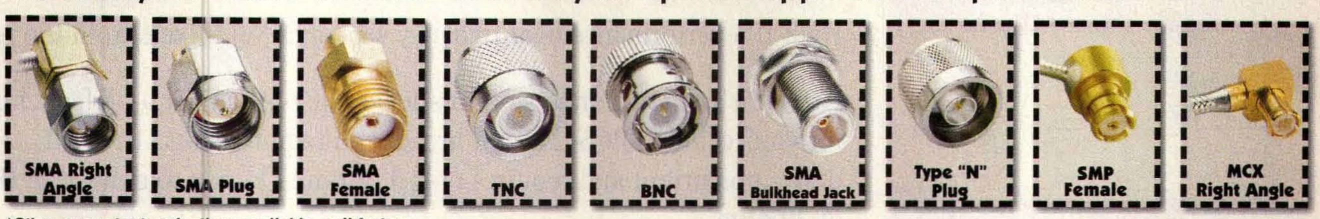

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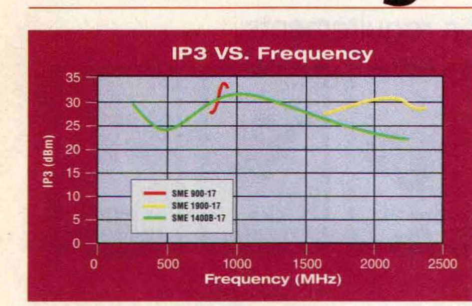

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SME 1400B-13	1-2200	1-2200	1-2000	+13	+9	+22	6.5	30
SME 1400B-17	1-2200	1-2200	1-2000	+17	+13	+27	6.5	30
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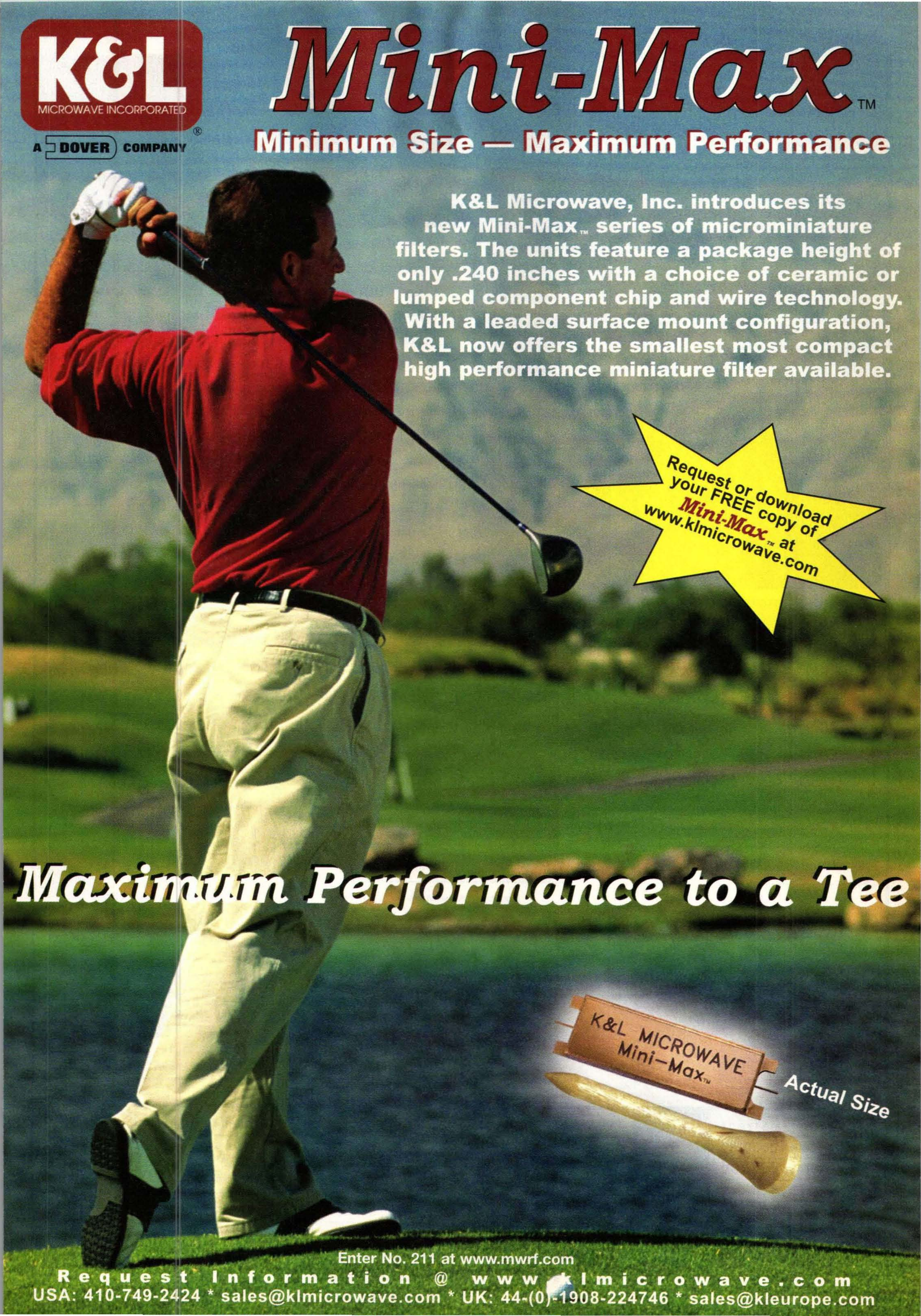

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the front end

News items from the communications arena.

Agreement Is Signed To Merge Wireless Business

WOBURN, MA AND NEWPORT BEACH, CA—Alpha Industries, Inc. and Conexant Systems, Inc. have announced the signing of a definitive agreement that will combine Conexant's wireless business with Alpha to create a pure-play power in RF and complete semiconductor system solutions for mobile communications applications.

Combining the wireless technology and product portfolios of both companies will position the new entity to influence the evolution of RF integration for all major air interfaces, including code-division multiple access (CDMA) and Global System for Mobile Communications (GSM), and complete semiconductor and software solutions for advanced second-and-a-half-generation (2.5G) and third-generation (3G) applications.

Under terms of the agreement, Conexant will spin off its wireless business, including its gallium-arsenide (GaAs) wafer-fabrication facility located in Newbury Park, CA, to be followed immediately by a merger of this business with Alpha. Upon completion of the merger, the new company will purchase Conexant's semiconductor assembly, module manufacturing, and test facility, located in Mexicali, Mexico, for $150 million in cash.

The merged company will have executive offices in Woburn, MA and Newport Beach, CA, and will employ approximately 4000 people worldwide. It will operate under a new name and ticker symbol that will soon be announced.

As a result of the merger, the new company's top four handset customers will consist of Nokia, Motorola, Sony/Ericsson, and Samsung, the world's largest handset original-equipment manufacturers (OEMs), and the company's top four infrastructure customers will be Ericsson, Motorola, Nokia, and Nortel—the world's largest infrastructure OEMs.

IEEE Standard 802.16 Gains Formal Approval

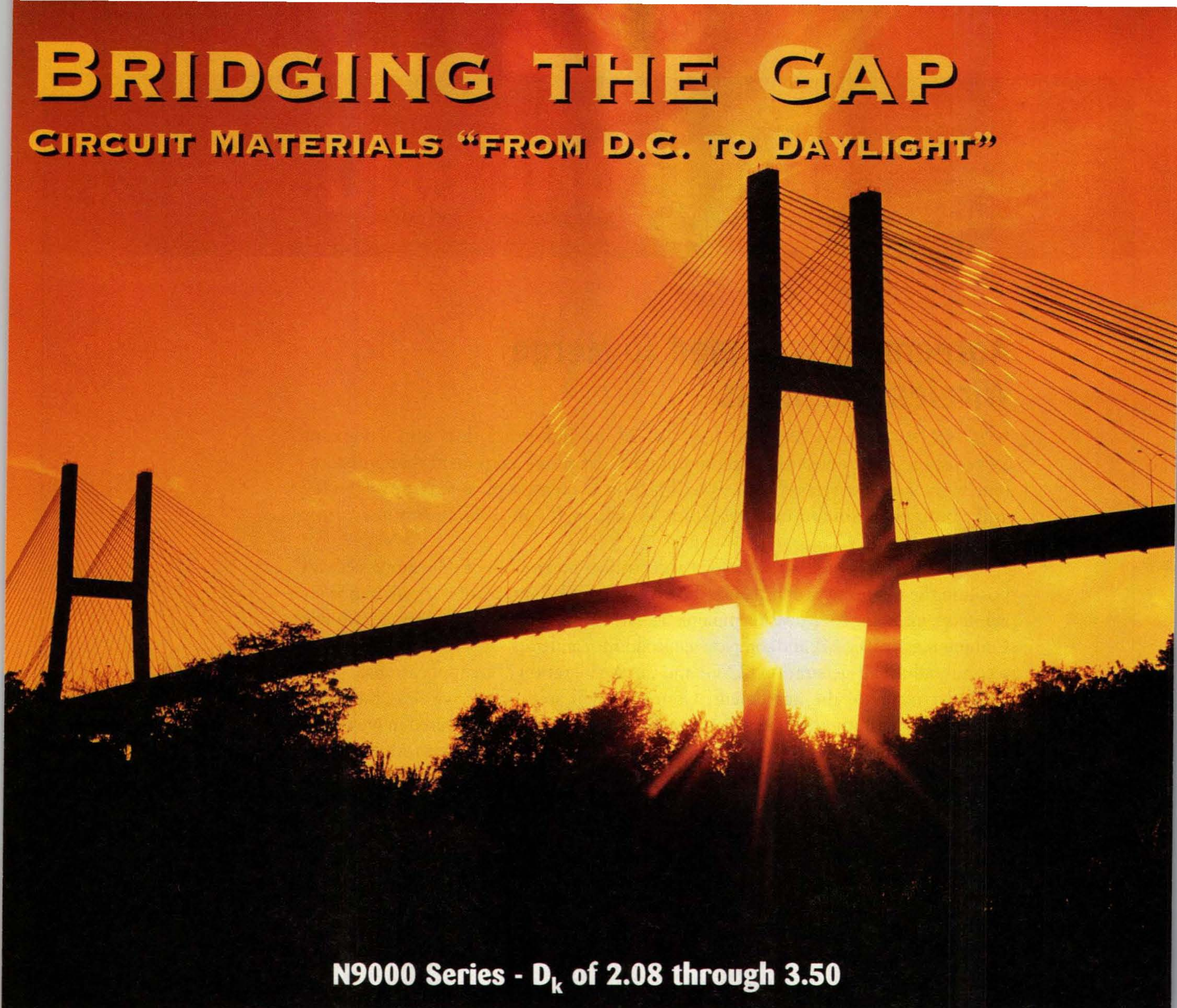
PISCATAWAY, NJ—The Standards Board of the Institute of Electrical and Electronic Engineers Standards Association (IEEE-SA) has formally approved IEEE Standard 802.16 ("Air Interface for Fixed Broadband Wireless Access Systems"). The approval sets the stage for the widespread deployment of 10-to-66-GHz wireless metropolitan-area networks as an economical method of high-speed "last-mile" connection to public networks.

The global IEEE 802.16 WirelessMAN air-interface standard is the first broadband wireless-access standard from an accredited standards body. It was published last month. The approved draft can also be viewed online at http://WirelessMAN.org/published.html.

"The new WirelessMAN standard is a groundbreaking development that changes the landscape for providers and customers of high-speed networks," says Roger Marks, Chair of the 802.16 Working Group on Broadband Wireless Access. "The standard makes highly efficient use of bandwidth and supports voice, video, and data applications with the quality that customers demand."

The 802.16 standard creates a platform on which to build a broadband wireless industry using high-rate systems that install rapidly without extensive metropolitan cable infrastructures. It was created in a two-year, open-consensus process that involved hundreds of engineers from the world's leading operators and vendors.

The standard enables interoperability among devices from multiple manufacturers.



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Cooperation Ensures Completion Of HiperLAN2 Standard

SOPHIA-ANTIPOLIS, FRANCE—The European Telecommunication Standards Institute (ETSI) and the HiperLAN2 Global Forum (H2GF) have signed a cooperation agreement that is intended to ensure the establishment of a global short-range broadband wireless infrastructure.

"Both ETSI and H2GF recognize the necessity to structure and strengthen their relationship and to foster close collaboration to make HiperLAN2, as a standard, a success. By cooperating with the HiperLAN2 Global Forum, we shall be able to ensure the largest possible market acceptance," comments Karl Heinz Rosenbrock, director general of ETSI.

"Both ETSI and H2GF recognize the necessity to structure and strengthen their relationship and to foster close collaboration to make HiperLAN2, as a standard, a success."

The HiperLAN2 specifications are being developed by ETSI Project BRAN. HiperLAN2 is a flexible radio local-area-network (RLAN) standard, designed to provide high-speed access [up to 54 Mb/s at Physical Layer (PHY)] to a variety of networks including third-generation (3G) mobile core networks, asynchronous-transfer-mode (ATM) networks, and Internet-protocol (IP)-based networks. It also can be used for private wireless-LAN (WLAN) systems. Basic applications include data, voice, and video, with specific quality-of-service (QoS) parameters taken into account. HiperLAN2 systems can be deployed in offices, classrooms, homes, factories, hot-spot areas such as exhibition halls and, more generally, where radio transmission is an efficient alternative to or complements wired technology.

HiperLAN2 marks a milestone in the development of a combined technology for broadband cellular short-range communications and WLANs which will provide performance comparable to that of wired LANs. Since the 5-GHz band to be exploited by the HiperLAN2 standard is allocated to WLANs worldwide, HiperLAN2 has the potential to enable the success of WLANs on a global basis.

Bluetooth ICs For Consumer Applications Released

MUNICH, GERMANY—After nine months of collaboration, Infineon Technologies AG and Toshiba Corp. announced the development of two new Bluetooth integrated circuits (ICs)—an RF transceiver and baseband device—which are supposed to be suitable for high-volume consumer product applications.

The two companies stated that a complete system solution for Bluetooth wireless connections in consumer products will be made available in the first quarter of 2002. Infineon is contributing its new PMB 626 RF transceiver, while Toshiba's semiconductor group is providing a new baseband IC, known as the TC35651.

The first products resulting from the Bluetooth partnership are aimed at consumer products with universal serial bus (USB) and Universal Asynchronous Receiver Transmitter (UART) functionality, said the two companies, which began their alliance in March 2001.

The Bluetooth baseband IC is fabricated with Toshiba's 0.18-μm complementary-metal-oxide-semiconductor (CMOS) technology and it operates on a +1.5-VDC power supply. The chip incorporates a reduced-instruction-set-computer (RISC)-based processor core, embedded static random-access memory (SRAM), and a pulse-code-modulation (PCM) digital audio interface that enables transmission of audio data, according to Toshiba. The IC also integrates interfaces for USB1.1 and UART. Samples of the TC35651 chip have been delivered to key customers, and mass production is slated to commence this quarter.

IEEE Gives Tentative Green Light For Speed Boost

PISCATAWAY, NJ—Technology corporations, through the Institute of Electrical and Electronics Engineers (IEEE), have tentatively approved a new standard known as 802.11g that reaches data-transfer rates of 54 Mb/s. The new standard is five times faster and compatible with wireless networking kits that use the popular 802.11b standard that is in use today.

The 802.11b networking kits, built by firms such as Cisco Systems, 3Com, Proxim, Intel, and Agere Systems, allow people to wirelessly connect their laptops together, so that they can roam around the house or office and still surf the Web. The technology has become popular over the past several years and has spread to coffee shops, airports, and hotels.

The IEEE is expected to approve the standard in a final vote that will take place this year, according to John Allen, a spokesman for the chipmaker Intersil.

Global-Phone Forecast For 2001 Is Slashed

NEW YORK, NY—Nokia has cut its expectations for overall sales of mobile phones worldwide in 2001. It is estimated that 380 million handsets were sold in 2001. Early in 2001, optimistic predictions had placed the number of projected sales for 2001 at 500 million. The downward turn in the economy made that optimistic forecast a virtual impossibility. In 2000, 408 million handsets were sold.

Still, Nokia maintains an optimistic outlook for this year. They still seek to corner 40 percent of the handset market in the long term. At the present time, Nokia controls approximately 33 percent of the global mobile-phone market. This year, between 420 million and 440 million mobile phones will be sold worldwide, according to Nokia's estimates. Nokia also predicts that worldwide wireless subscribers will surpass the 1 billion mark during the first half of this year, and grow to 1.5 billion users by 2005.

As mobile-phone penetration rates rise worldwide, some analysts are concerned that upcoming next-generation networks and phones may not lure subscribers to buy a new phone if there are not any compelling and useful services available. But Nokia's executive vice president Anssi Vanjoki recently told Reuters that the company expects handset replacement to reach levels of 70 to 80 percent based on desire for advanced options including wireless photography, audio, and multimedia messaging.

SOI Process Uses Hybrid Trench Isolation

MAKUHARI, JAPAN—Mitsubishi Electric Corp. plans to adopt a version of silicon-on-insulator (SOI) technology that uses hybrid trench isolation and dual-gate oxides to create a new generation of high-speed communication integrated circuits (ICs) and possibly RF/analog circuits, according to the *EE Times*.

Mitsubishi's 0.18-μm SOI complementary-metal-oxide-semiconductor (CMOS) technology overcomes the floating-body and hot-carrier effects that have previously made SOI unsuitable for high-voltage operation, comments Shigeto Maekawa, group manager at Mitsubishi's ULSI development center in Osaka, Japan.

"Hybrid trench isolation is the combination of partial trench isolation and full trench isolation."

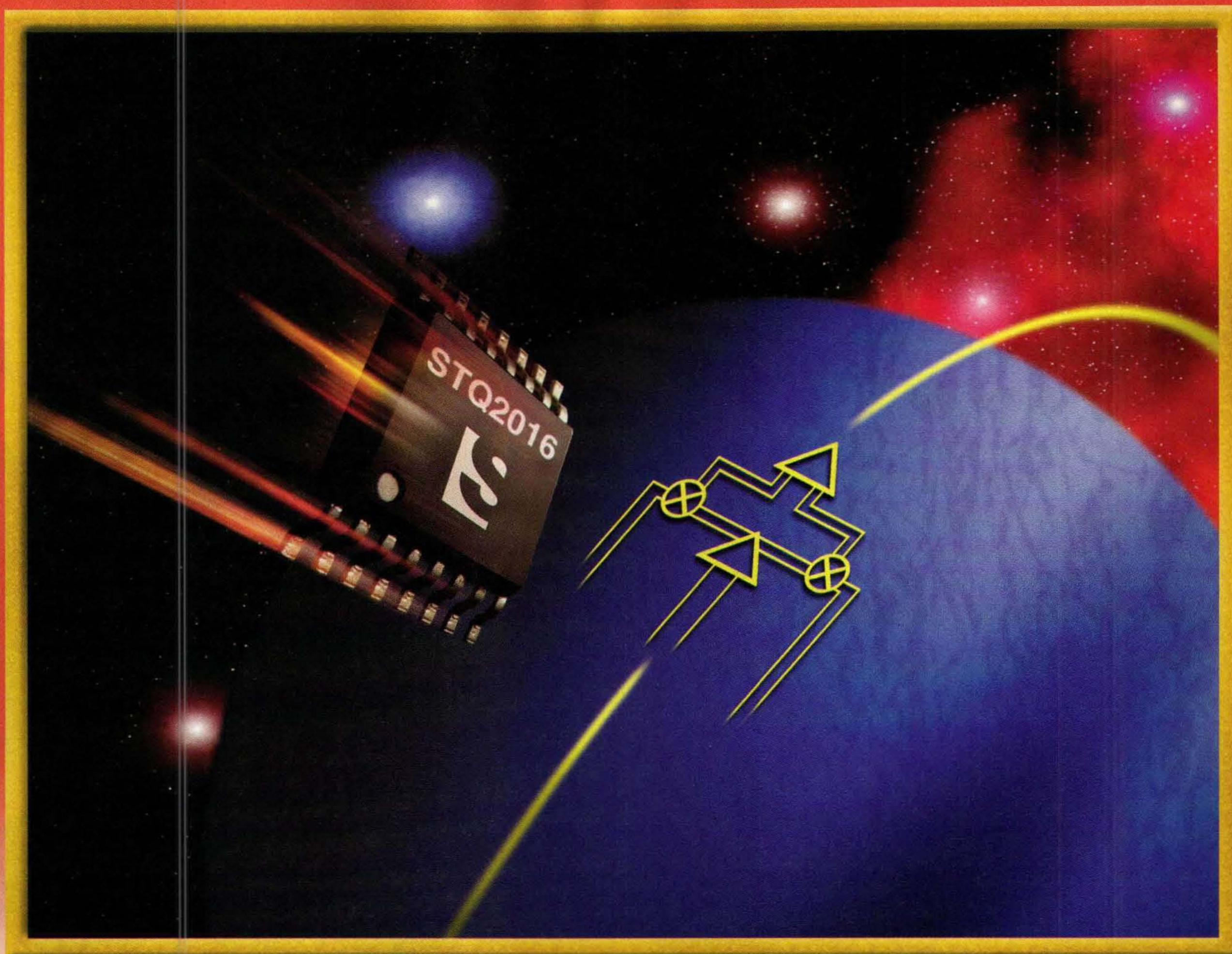
Mitsubishi plans to use the technology to manufacture these communications ICs as 2.5-Gb/s multiplexers/demultiplexers for synchronous digital hierarchy (SDH) and Synchronous Optical Network (SONET), says Maekawa, but he declined to reveal when this would happen.

While another company has reportedly developed a +2.5-VDC dual-oxide SOI process, Mitsubishi is the first to develop an SOI CMOS process featuring the more common +3.3-VDC supply, Maekawa offers.

Mitsubishi employs hybrid trench isolation to create a stable process. "Hybrid trench isolation is the combination of partial trench isolation and full trench isolation," Maekawa states. "This device structure is rare—a Mitsubishi original."

Kudos

LPKF Laser & Electronics is celebrating 25 years of designing and manufacturing prototyping systems. Since the late 1970s, thousands of companies have used LPKF systems every day for the generation of high-speed digital, analog and mixed technology, wireless, RF, and microwave applications...Anaren Microwave, Inc. has received patents for two inventions in the microwave-component arena. Jeff Merrill, an Anaren design engineer, earned US Patent 6,292,070 for his "balun formed from symmetrical couplers" and the manufacturing process required for making the new part. In partnership with Merrill, Anaren product manager Hans Peter (H.P.) Ostergaard also earned US Patent 6,294,965 for a "stripline balun"...Japan's wireless operator KDDI and Motorola jointly celebrated a significant industry milestone on November 6, 2001 when the 10 millionth mobile subscriber was registered on KDDI's cdmaOne™ network. It is Japan's first code-division-multiple-access (CDMA) digital cellular network and the infrastructure was solely designed, manufactured, and installed by Motorola...Wireless Valley Communications, Inc., a developer of software products for the design, measurement, and management of in-building and campus networks, announced that it has been awarded US Patent 6,317,599 for its SitePlanner® wireless design and management software...StratEdge has received US Patent 6,271,579 for its High Frequency Passband Microelectronics Package. MRF



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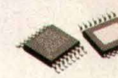

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STQ-3016†	2500–4000	+1	-40	33	50	-153	-6	±2.5	±0.10

*f_{LO} = 2,000 MHz; †f_{LO} = 3,500 MHz

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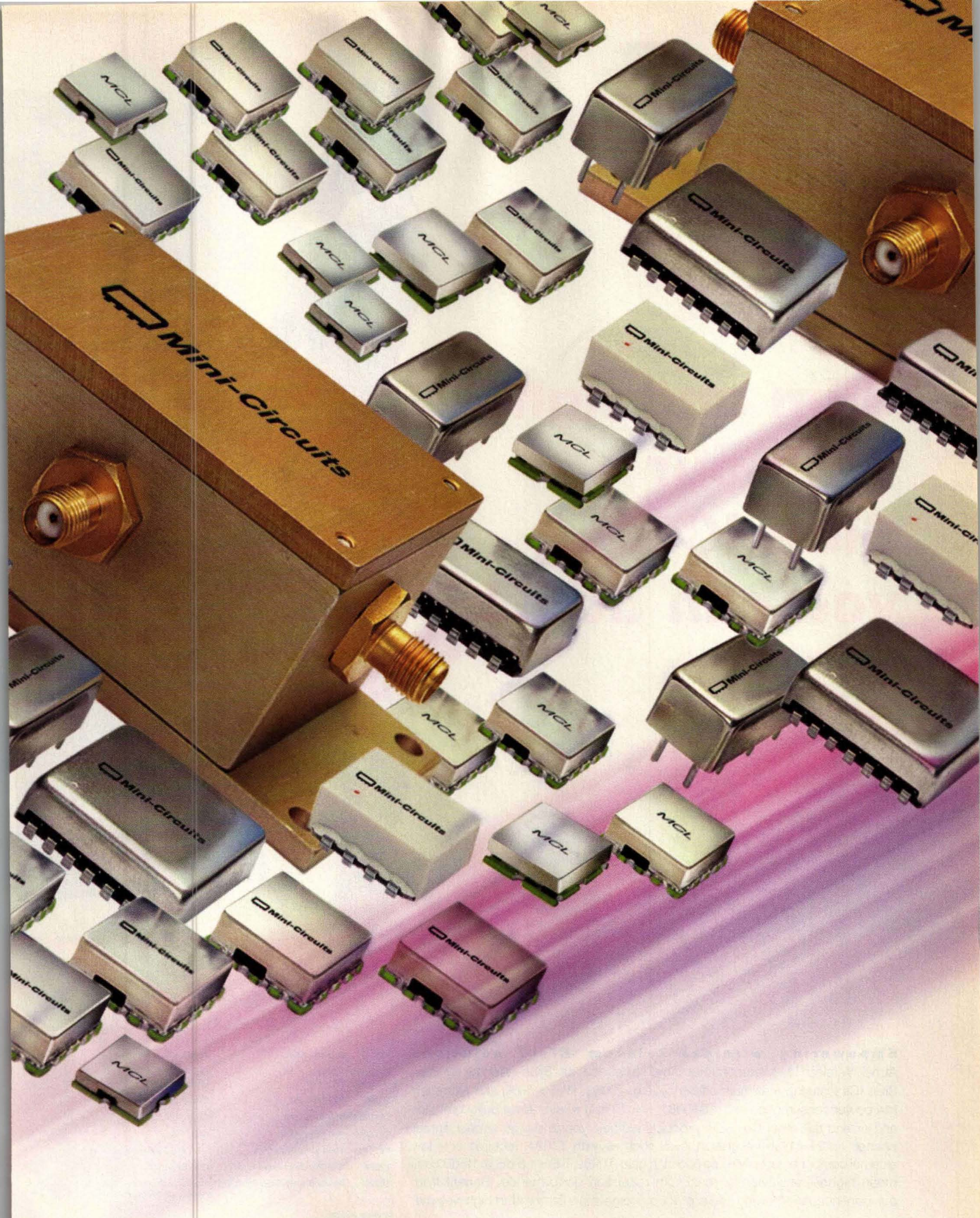
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NEWS

Seeking Light At The End Of The Fiber

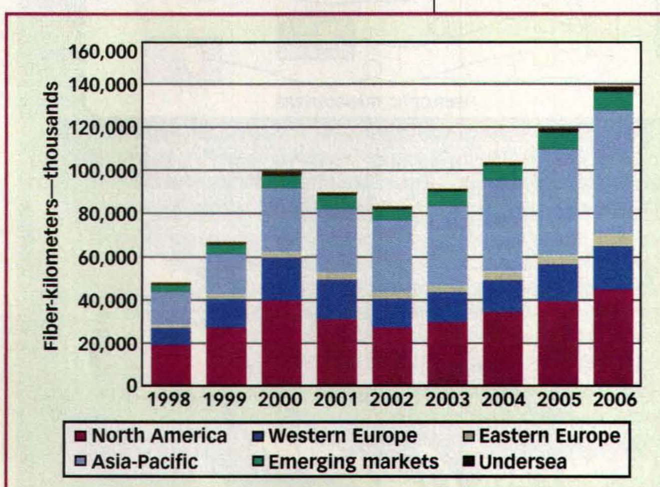
Although fiber markets slowed during 2001, the push for fast data rates and instant Internet access should drive optical-communications markets through 2006.

JACK BROWNE
Publisher/Editor

Optical-communications technology continues to advance in the quest for increased bandwidth and faster data rates, even though the market for this technology slowed dramatically during 2001. Still, driven by an almost-insatiable consumer and business demand for faster Internet and e-mail service and improved data transmissions, many manufacturers of optical-communications cables, components, and test equipment remain optimistic about opportunities for growth during the next several years.

Several research reports point to growth beyond 2002, albeit with cautious optimism. According to optical market researchers at KMI Research (Providence, RI; www.kmicorp.com), for example, the worldwide market for fiber-optic cable should reach $11.8 billion in 2006 **(Fig. 1).**

The company recently updated its market projections based on changing market conditions during the past two years, developing projections through 2006 for more than 200 fiber-optic cable facilities and 65 optical-fiber production facilities worldwide in its recently released report *Worldwide Optical Fiber and Fiberoptic Cable Markets: Analyses & Forecasts of Installations & Production.* According to Patrick Fay, a KMI Research analyst and author of the research report, a surplus of optical fiber was manufactured in 2001, affecting the projections and needs for the next several years. He says that there was simply "too much investment in new fiber networks and too



1. This plot shows projected worldwide deployment of optical fiber by region in thousands of fiber kilometers. (Plot courtesy of KMI Research, Providence, RI.)

many operators in several key geographic markets. So the market is now correcting for these excesses." He expects growth to resume in the fiber-optic cable market in 2003.

KMI also recently projected tremendous growth for optical fiber in China, with fiber-production volume rising from 5.8 million fiber kilometers in 2000 to 16.4 million fiber kilometers by 2005. This translates into a 27-percent compound annual-growth rate (CAGR). According to the KMI report, *Optical Fiber and Fiber-Optic Cable Markets in China-Carrier Profiles and Market Forecasts,* China will use approximately 16 million fiber kilometers from overseas suppliers each year between 2001 and 2005. Domestic fiber suppliers provided the nation with 7 million fiber kilometers in 2001, and this figure is expected to rise to 16 million fiber kilometers by 2005. At present, China already has more than 200 fiber-optic cable manufacturers, although they only achieved approximately 22 percent of capacity during 2001.

In another report, *Automated Assembly & Test of Fiber Optic Components,* from ElectroniCast Corp. (San Mateo, CA; www.electronicast.com), the global consumption of fiber-optic component-assembly equipment and related test equipment is expected to grow rapidly over the next several years. The $722 million market figure of 2000 is projected to balloon to a $1.71 billion market by 2005, despite a decline in the market to only $429 million in 2001. These markets consist of several components, including fiber-alignment and attachment equipment with an approximately 29-percent share of the 2000 market (or about $211 million), while test equipment, although a smaller portion of the total market, showed slightly faster growth. According to ElectroniCast founder and Chairman Jeff Montgomery, the unit price of optical assemblies will dictate the need for automated assembly equipment in the future. "There are few vendors now with production rates of 1000 per day or more for any product family," he notes. "The near-term challenge, therefore, for automated assembly vendors is to develop product-specific automated assembly lines to sell at an appropriate price level, that can be reasonably amortized with relatively low-priced components," adds Montgomery.

Still, leading firms in optical communications, such as Corning, Inc. (Corning, NY; www.corning.com) and JDS Uniphase Corp. (San Jose, CA; www.jdsu.com), recently reported poor financial numbers for their most recent quarters. Corning, for example, reported a pro forma (after deductions) net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loss of $261 million or $0.28 per share for the fourth quarter ending December 31, 2001. This compares to earnings of $307 million or $0.33 per share for the fourth quarter of 2000. The company's fourth-quarter 2001 sales were $974 million, compared to $2.1 billion for the same quarter of the previous year. Late last month, JDS (which recently acquired the optical-transceiver business of IBM), reported sales of $286 million for their second quarter ending December 31, 2001. This is 13 percent below the sales of $329 million reported for the first quarter ending September 29, 2001. The $286 million also compares poorly to the $925 million in second-quarter sales of 2000.

A great deal of new-product activity is presently focused on OC-192 at 10 Gb/s. California Eastern Laboratories (Santa Clara, CA; www.cel.com), for example, offers the model NX8560LJ-CC electroabsorption (EA) 1550-nm laser-diode modulator with transmission capability to 40 km using single-mode fiber at 10 Gb/s. The company's model NR4270MU-CC superlattice avalanche-photodiode (APD) receiver (Rx) provides better than –24 dBm Rx sensitivity at 10 Gb/s.

Agere Systems (Allentown, PA; www.agere.com) last fall announced the first 10-Gb/s EA-modulated laser with an internal driver, capable of operating distances to 80 km. The E2581 series combines a continuous-wave (CW) laser with an EA modulator on the same integrated circuit (IC), and adds an integral driver IC for improved transmission performance. The device is suitable for use in Synchronous Optical Network/synchronous digital hierarchy (SONET/SDH) or dense-wavelength-division-multiplex (DWDM) optical-network systems.

Oki Semiconductor (Sunnyvale, CA; www.okisemi.com) offers the model OD9652N module with a 10.7-GHz optical Rx and preamplifier. The combination of the two components with additional bandwidth simplifies the implementation of forward-error correction (FEC) in optical networks. Princeton Optronics (Princeton, NJ; www.princetonop-

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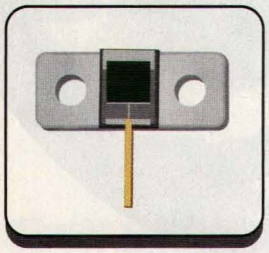

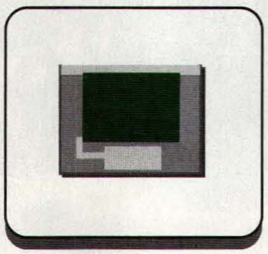

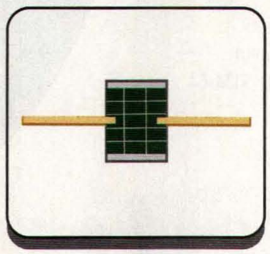

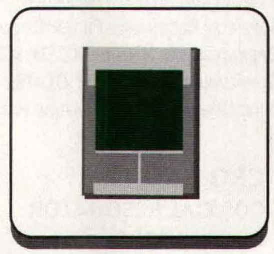

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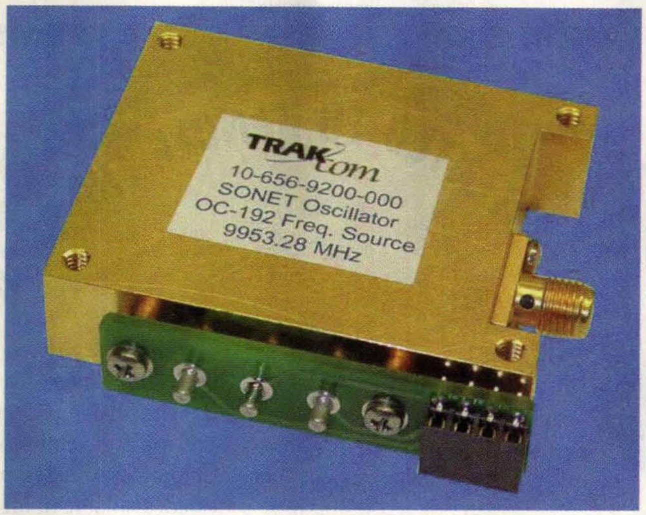
tronics.com) also offers a SONET/SDH Rx, the model RXPB1250, with bandwidth to 12.5 Gb/s.

Even manufacturers traditionally associated with microwave markets, such as TRAK Microwave (Tampa, FL; www.trak.com), have begun to develop components for optical communications. The company's newly announced model 10-656-9200 oscillator **(Fig. 2)** is designed for OC-192 SONET, clock timing, and clock-recovery phase-locked-loop (PLL) applications. The 10-GHz oscillator offers an output buffer amplifier for increased drive levels and a 20-MHz tuning range with tuning voltages of –5 to +5 VDC. The low-phase-noise source is supplied in a surface-mount package measuring only 2.0 × 2.0 × 0.5 in. (5.08 × 5.08 × 1.27 cm).



2. The model 10-656-9200 oscillator is designed for 10-Gb/s OC-192 SONET/SDH systems. (Photograph courtesy of TRAK Microwave, Tampa, FL.)

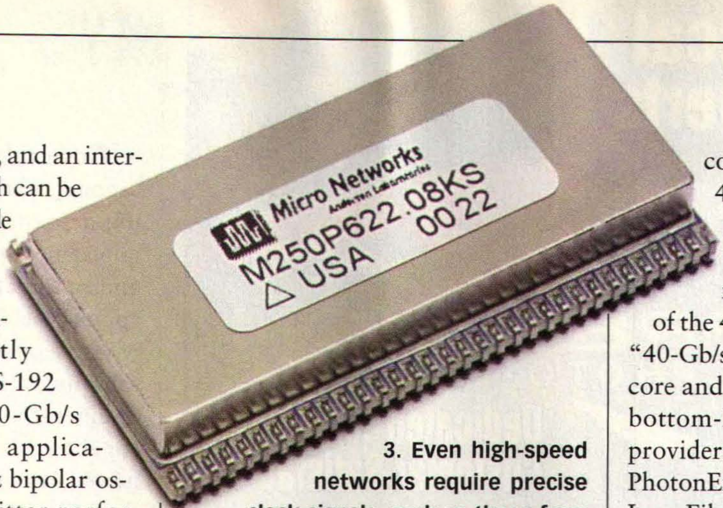
In addition, the company's recently announced 50-20X-40XX-000 series of bandpass cavity filters has been developed for OC-192 SONET/SDH and optical-clock data-recovery applications. The filters achieve less than 4-dB insertion loss in a surface-mount package that measures only 31.8 × 15.2 × 11 mm.

Micro Networks Corp. (Worcester, MA; www.micronetworks.com), a firm associated with precision frequency sources, announced a new clock generator for use in 10-Gb/s Ethernet optical-communications systems. The company's model M250 **(Fig. 3)** clock generator provides synchronous output frequencies of 155.52, 311.04, and 622.08 MHz for use as clock signals in high-speed optical-communications networks. The clock generator operates with an input

frequency of 19.44MHz, and an internal reference clock, which can be activated by an "input mode select" control signal.

Elcom Technologies (Rockleigh, NJ; www.elcom-tech.com) recently launched its model COS-192 clock oscillator for 10-Gb/s SONET/SDH OC-192 applications. The 9.95328-GHz bipolar oscillator achieves low jitter performance despite consuming less than 1 W of DC power. The phase noise is only –95 dBc/Hz offset 10 kHz from the carrier, dropping to a miniscule –115 dBc/Hz offset 100 kHz from the carrier. With a tuning range of 20 MHz, the source features modulation sensitivity of 1.75 to 3.5 MHz/V.

But the future of optical communications may lie at 40 Gb/s. PhotonEx Corp. (Maynard, MA; www.photonex.com) recently announced the founding of the 40G Collaborative, a business alliance committed to the commercialization of deployable 40-Gb/s solutions for the core public-services network. According to Dr. Kristin Rauschenbach, president, CEO, and cofounder of PhotonEx, "The 40G Collaborative represents a number of the most innovative technology advancements." He notes that the goal of the 40G Collaborative is to bring "40-Gb/s functionality to the network core and ensure top- line growth and bottom-line advantages for service providers worldwide." In addition to PhotonEx, members include Corning, Inc., Filtronic plc (Santa Clara, CA; www.fil tronic.com), JDS Uniphase Corp. (Melbourne, FL; www.jdsu.com), LaserComm, Inc. (Plano, TX; www.lasercomm-inc.com), Lightwave Microsystems Corp. (San Jose, CA; www.lightwavemicro.com), Microwave Concepts, Inc. (Fairfield, NJ; www.micro-con.com), New Focus, Inc. (San Jose, CA; www.newfocus.com), Onetta, Inc. (Sunnyvale, CA; www.onetta.com), and Optigain, Inc. (Peace Dale, RI; www.optigain.com).



3. Even high-speed networks require precise clock signals, such as those from the model M250 clock generator with synchronous output frequencies of 155.52, 311.04, and 622.08 MHz. (Photograph courtesy of Micro Networks, Worcester, MA.)

NEWS

Products for OC-768 40-Gb/s applications are beginning to appear, including a preproduction line of transimpedance amplifiers, photoreceivers, and modulation drivers from TRW spinoff Velocium (El Segundo, CA; www.velocium.com). Corning is now sampling a line of 40-Gb/s lithium-niobium-oxide ($LiNbO_3$) modulators for 40-Gb/s DWDM systems. The modulators feature extinction ratios exceeding 10 dB and jitter as low as 2 ps. And Fujitsu Ltd. (Tokyo, Japan; www.fujitsu.co.jp) last month announced a 40-Gb/s optical transmitter (Tx) module using a $LiNbO_3$ Mach-Zehnder optical external modulator and a double-heterostructure high-electron-mobility-transistor (HEMT) driver-amplifier IC.

Agilent Technologies (Santa Rosa, CA, www.agilent.com) recently announced the addition of its models VTO-3981-SMD and VTO-4301-SMD surface-mount voltage-controlled oscillators (VCOs) with operating frequencies of 39.813 and 43.018 GHz, respectively, for OC-768 and STM-256 applications. These sources are suitable for data retiming in optical Tx subsystems and for data recovery in 40-Gb/s optical Rxs. The oscillators are based on low-noise bipolar transistors in conjunction with a hyperabrupt varactor-tuning diode. The output of each oscillator is coupled to a gallium-arsenide (GaAs) monolithic-microwave-integrated-circuit (MMIC) amplifier and MMIC multiplier to quadruple the internal frequency to the final 40- or 43-GHz frequency.

Each differential-output VCO provides at least 0-dBm output power with modulation sensitivity ranging from 40 to 80 MHz/V. Jitter is less than 50 fs from 50 kHz to 80 MHz removed from the carrier. For those more familiar with the frequency domain, the phase noise is only –95 dBc/Hz offset 100 kHz from a 40-GHz carrier. The VCOs are supplied in a surface-mount package measuring only 1.18 × 0.95 × 0.40 in. (3.00 × 2.41 × 1.02 cm). MRF

Filters target STL-band applications

A LINE OF broadcast-quality, ultranarrow bandpass cavity filters is available for use in 900-MHz STL Rxs. Designed as preselector filters, these cavities offer rejection of better than 80 dB. The filters are available for US and Canadian STL bands and can be pretuned to the customer's exact STL frequency. Applications include rejection of other STL signals, paging services, and cellular-phone-band noise. P&A: less than $500.00 ea.; one week.

Integrated Microwave Corp., 11353 Sorrento Valley Rd., San Diego, CA 92121; (858) 259-2600, FAX: (858) 755-8679, Internet: www.imcsd.com.

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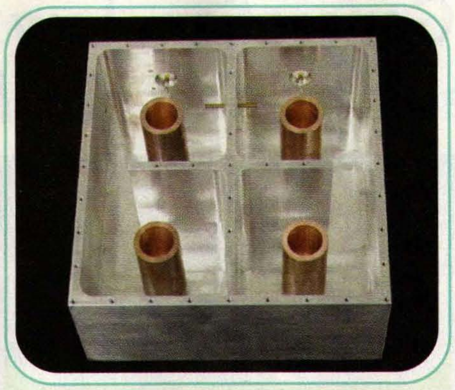
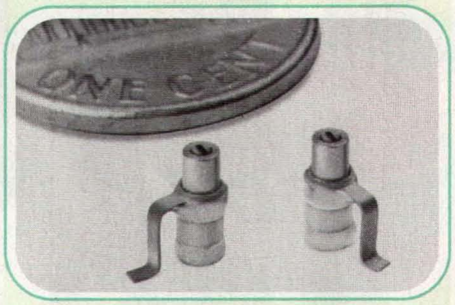


INTEGRATED MICROWAVE CORP. CAVITY FILTERS



VOLTRONICS CORP. TRIMMER CAPACITORS

Switches simplify ATE-system design

MODELS 1260-162A/B AND 1260-164A/B are high-density, long-life, two-slot switch cards that address the market need to increase the flexibility and simplify the design of existing ATE systems. The plug-ins enable users to switch high-density signals in only two VXI slots, and support rapid switch-card expansion and replacement. Narda switches facilitate user-specific test configurations with high repeatability and accurate system calibration. The 1260-162A contains one transfer switch and the 1260-162B contains two. The 1260-164A contains one SP4T switch and the 1260-164B contains two. All four models are equipped with an 18-GHz bandwidth, switching life of one million operations (minimum), along with drivers for LabWindows/CVI and LabVIEW for VXI applications. They are programmable through GPIB commands when they are used with the 1256 switching system. Windows platforms are supported. P&A: $1995.00 ea.

Racal Instruments, Inc., 4 Goodyear St., Irvine, CA 92618; (800) 722-2528, (949) 859-8999, FAX: (949) 859-7139, e-mail: sales@racalinstruments.com, Internet: www.racalinstruments.com

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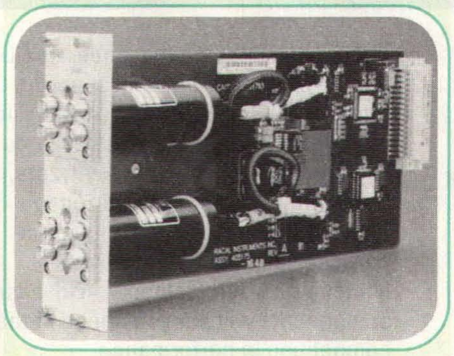
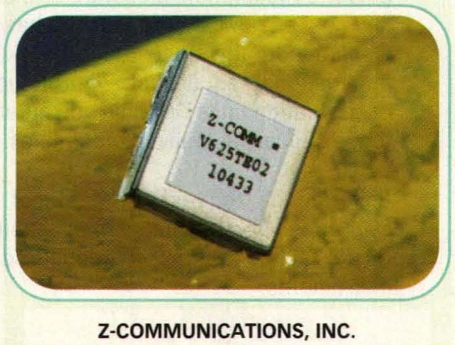


RACAL INSTRUMENTS, INC. SWITCHES



Z-COMMUNICATIONS, INC. VCO

Capacitors replace sapphire trimmers

THE A2 SERIES of 1.2-pF multi-turn precision trimmer capacitors is meant to replace sapphire trimmers. Voltage is +250 VDC working and +500 VDC withstanding. A high-voltage option has +1250 VDC working and +2500 VDC withstanding. Capacitor range is 0.3 to 1.2 pF and temperature coefficient is 0 ±150 PPM/°C from –65 to 125°C. Q is greater than 1000 at 1 GHz and self-resonant frequency is greater than 5 GHz. Tuning is linear over four full turns with positive stops at minimum and maximum capacitance. Footprint size is 0.24 × 0.09 in. (0.61 × 0.23 cm). P&A: $1.60 (100,000 qty.); 1 wk. for samples and 4 wks. for more than 1000 qty.

Voltronics Corp., 100 Ford Rd., Denville, NJ 07834; (973) 586-8585, FAX: (973) 586-3404, e-mail: info@voltronicscorp.com, Internet: www.voltronicscorp.com.

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VCO operates to 1816 MHz

MODEL V625TE02 IS a VCO that generates frequencies from 1755 to 1816 MHz. Tuning voltage is +1 to +4 VDC, enabling a design engineer to integrate the VCO into a PLL where the error voltage can be taken directly from the IC's charge-pump circuitry. Phase noise is –105 dBc/Hz at 10-kHz offset, while harmonic suppression is –10 dBc and tuning sensitivity is 30 MHz/V. Output power is 2 ±3 dBm and load impedance is 50 Ω. With an input capacitance of 50 pF maximum, pushing is less than 1 MHz/V. Pulling is less than 2 MHz at 14-dB return loss in any phase and operating temperature range is –40 to 85°C. Supply voltage is +5 VDC. P&A: $15.95 ea. (1000 qty.).

Z-Communications, Inc., 9939 Via Pasar, San Diego, CA 92126; (858) 621-2700, FAX: (858) 621-2722, e-mail: sales@zcomm.com, Internet: www.zcomm.com.

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Nowhere But Up For Telecom

UNCERTAINTY ABOUT the war on terrorism, falling consumer confidence, and poor performance by wireless phone providers are weighing on an already struggling telecommunications industry, making 2002 look like it will be a year of more downs than ups for business.

For example, a recent report from the Yankee Group says that handset sales in Europe declined by 8 percent in 2001 and will grow at only a 2.4 percent rate in 2002. Last year was the first to show a contraction in sales and future years will not see the double-digit growth of the past, according to the report. Wireless service providers received a negative report recently when Consumer Reports said that many users find themselves in a "cell hell" of dropped and blocked calls, limited calling range, coverage holes, and yet-to-be-implemented emergency services. Consumers Union called on the FCC to force carriers to make changes.

On the bright side, large wireless providers such as Cingular and AT&T are installing GSM systems in the US in a bid to corner the market on 3G users (see *Microwaves & RF*, January 2002, p. 44). The key component of 3G GSM systems is the GPRS, which will provide callers with advanced data features such as multimedia messaging, broadband Internet access, and color video. In Europe, the capability for roaming is thought to be the essential element for widespread adoption of GPRS, according to a report by the research firm Analysys.

While the US was considered years behind Europe in deploying faster wireless services, Cingular and AT&T are not letting any grass grow under their feet in putting GPRS capability into play. AT&T announced last November that it was deploying the service in three areas of Michigan—Detroit, Flint, and Ann Arbor—and Toledo, Ohio. Meanwhile, Cingular instituted a GPRS system with roaming that will cover customers in Las Vegas, Spokane, and Seattle. The roaming agreement allows a Cingular customer to roam wherever any carrier offers GPRS. Investment in new infrastructure for GSM and GPRS bodes well for US telecommunications. MRF

CONTRACTS

Sensytech, Inc.—Has received contract awards of $2.6 million for delivery of communications and signal-analysis equipment.

MegaPhase—Announced that it is the recipient of a follow-on contract for nine more systems from customer L3 Communications/Randtron Antenna Systems. The contract is valued in the low six figures and will supply airborne coaxial cables used inside a radar, built for the US Navy's Cooperative Engagement Capability systems.

DRS Technologies, Inc.—Will be manufacturing and assembling platform pedestals and other support hardware for the AN/FPS-117 Long-Range Early Warning Radar Systems. The AN/FPS-117 Radar Systems are built for US, NATO, and allied forces. For the $4.9 million award, the company's DRS Surveillance Support Systems unit in Largo, FL will provide platform pedestals and array central enclosures, which include central enclosures, antenna wing assemblies, service lift and support assemblies, and doors. Product deliveries are expected to continue through November of this year.

Giga-tronics, Inc.—Revealed that its Microsource subsidiary has received multiyear contract awards in excess of $7 million from The Boeing Co.

Lockheed Martin Naval Electronics & Surveillance Systems—Radar Systems—Won a contract to provide three mobile radar systems to the Republic of Korea Air Force (ROKAF). The TPS-117 transportable radar systems—along with integrated air operations, communications, and logistics support—will be delivered by the end of the first quarter of 2004.

FRESH STARTS

MCE/Inmet—Restructured its distribution network for the US and Canada. With the elimination of traditional sales boundaries, MCE/Inmet has appointed four authorized distributors to serve all of the US and Canada. The distributors are Argosy Component Sales of Bellevue, WA; Bayshore Communications, Inc. of San Jose, CA; M&S Electronics, Inc. of Haddonfield, NJ; and Sun Moon Electronics of Plano, TX.

Wireless Valley Communications, Inc.—Announced its plans to relocate corporate headquarters to Austin, TX. The move is expected to be completed during the second quarter of this year.

Electro Dynamics Crystal Corp. (EDC)—Has acquired the precision OCXO product line from Electronics Research Co. (ERC) of Overland Park, KS. Movement of the manufacturing resources into EDC's Overland Park plant was completed during December.

Zetex—Launched a new website at www.zetex.com. The site covers the company's range of integrated, discrete, and combination products. Analog solutions are identified through free text, full or partial part-number searches, or from IC discrete product-category listings. Data sheets are offered in 'view online' and 'receive by e-mail' modes. Application notes and design notes are also made available as downloadable documents.

Amcom Communications, Inc.—Appointed Trionic Associates, Inc. of Great Neck, NY to be the exclusive representative for the metropolitan New York territory including northern New Jersey. Amcom designs and manufactures GaAs FET power semiconductor devices and MMICs.

Unical Enterprises, Inc. and Eleven Engineering, Inc.—Announced intentions to develop and market wireless products targeting the video-game industry. The ensuing products will implement Eleven's XISPIKE™ ("SPIKE") RF technology and will be integrated into a line of products sold under the Sylvania™ brand.

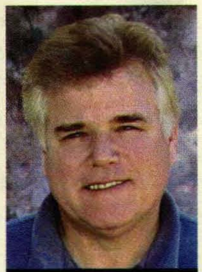
Zyray Wireless—Has completed the expansion and relocation of its headquarters. The expansion was completed to provide additional office space to support increased headcount, expanded lab and testing facilities, advanced product development, and customer interaction. Located in the Carmel Valley area of San Diego, the new address is 11455 El Camino Real, Suite 350, San Diego, CA 92130. Carmel Valley is located 20 miles north of downtown San Diego, and is part of the city's expanding wireless technology corridor.

Accelerated Technology, Inc. (ATI) and MetaWare, Inc.—Announced that they have furthered their relationship by signing an agreement for ATI to distribute and support MetaWare products worldwide. According to the agreement, ATI will be bundling MetaWare's HighC/C++/EC++ compiler tools as part of ATI's code|lab Embedded Developer Suite.

RedVector.com—Has been approved as a Continuing Education Provider by the Florida Board of Professional Engineers (FBPE). The approval allows the more than 27,000 licensed engineers in Florida to complete their state-mandated continuing education hours online at the RedVector.com website at www.redvector.com.

AVX Corp. and Lucent Technologies—Entered into a strategic alliance agreement with Lucent designed to use AVX's component technologies to enhance Lucent's product development and time-to-market conditions. The agreement is part of Lucent's Supplier Relationship Program, in which Lucent and AVX will collaborate on cost-reduction initiatives and design, share technology roadmaps, and work together to reach mutually developed business goals.

GHz Technology—Signed a letter of intent to merge with Advanced Power Technology (APT), a provider of power semiconductors. APT is a global manufacturer with ISO-9001-certified wafer-fabrication and packaging facilities located around the world. APT serves customers in the communications, semiconductor capital equipment, medical, industrial, and military/aerospace sectors. GHz Technology is a supplier of high-power transistors for radar, avionics, and microwave applications. MRF



MOORE

Celerity Names Moore To President And GM Position

Celerity Systems, Inc. announced that BRUCE MOORE has joined the company as president and general manager. He was formerly a senior manager with the KPMG Consulting Financial Services, responsible for marketing and business development.

Racal Instruments—JACK POUCHET to director of corporate communications for the Racal Instruments group of companies; remains as marketing director.

Quake Global—KAREN L. DUNHAM to regional sales manager; formerly regional director with Orbcomm Global. Also, MARK JONES to vice president of product development and CTO; formerly employed as lead systems and DSP engineer responsible for development of DSP and support software for satellite communicators at Torrey Communications.

Gel-Pak—RON LECKIE to the board of directors; remains as the CEO of Infrastructure.

Schema Ltd.—BRADLEY BARAKAT to sales director for North America; formerly senior manager of market development for Nortel Networks. Also, SHOKEN KIM to sales director for Asia Pacific; formerly vice president for Asia Pacific operations at SAFCO Technologies, Inc. And, ORI LEVY to sales director for Europe, Middle East, and Africa (EMEA); formerly responsible for EMEA and Asia sales with WaveACCESS. In addition, LUIS RUGELES to sales director for Latin America; formerly sales director for wireless infrastructure at Motorola in the Caribbean and Andes region.

Park Electrochemical Corp.—KENT FRAZIER to senior director of global marketing and sales for RF/microwave materials; formerly manufacturing representative for JPD Industries, Inc.

IPC—STAN PLZAK to chairman of the board; remains as executive vice president of SMTC Manufacturing Corp. Also, PETER MURPHY to chairman-elect; remains as president and CEO of Parlex Corp. In addition, LEO REYNOLDS to secretary/treasurer; remains as president and CEO of Electronic Systems, Inc.

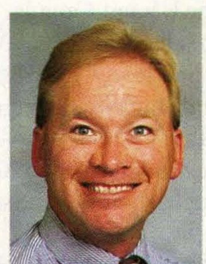
TRAK Communications, Inc.—MICHAEL BRANCA to vice president and CFO; formerly CFO at Reptron Electronics.

Scott Specialty Gases—KEN EICHELMANN to product manager for SCOTTY Transportable Products; formerly director of sales and marketing with Scott/Bacharach Instruments.

MariTEL—LAWRENCE R. FYOCK to vice president of sales; formerly vice president of sales and marketing for Digital Access, Inc.

Eleven Engineering—DON THOMAS to vice president for client relations; formerly third-party peripherals manager for Sony Computer Entertainment of America.

Racal Instruments—JOHN ROSENWALD to business development manager for the Military-Aerospace Test Group; formerly lead technical consultant for critical ATE with the US Air Force.



ROSENWALD

HUBBARD

Century Tel, Inc.—MICHAEL HUBBARD to director of data services development in the emerging applications dept.; formerly senior manager responsible for product management and development at Lucent Technologies. MRF

▸ SHORT COURSES

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Commercial High-Performance Computing Conference
March 19-20 (Hyatt Orlando, Orlando, FL)
Intermedia Group and Illuminata
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Fundamentals of Cellular and PCS Wireless Communications
April 9-11 (Madison, WI)
University of Wisconsin, Madison
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Dept. of Engineering Professional Development
Madison, WI 53706
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▸MEETINGS

Wireless Systems Design Conference & Expo 2002
February 25-28 (San Jose Convention Center, San Jose, CA)
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Hasbrouck Heights, NJ 07604
(888) 947-3734
e-mail: electronicsevents@penton.com
Internet: www.wirelesssystems2002.com

ICAPS 2002 International Conference on Advanced Packaging and Systems
March 10-13 (Reno Hilton Hotel, Reno, NV)
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March 12-15 (Shanghai New International Expo Center, Shanghai, China)
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Embedded Systems Conference San Francisco
March 12-16 (Moscone Center, San Francisco, CA)
CMP Media LLC
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IEEE Sarnoff Symposium 2002—Advances in Wired and Wireless Communications
March 13 (The College of New Jersey, Ewing, NJ)
IEEE Princeton Section, IEEE Microwave Theory and Techniques Society (MTT-S), TCNG Engineering Dept.
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CTIA Wireless 2002
March 18-20 (Orange County Convention Center, Orlando, FL)
Cellular Telecommunications & Internet Association
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Internet: www.ctiashow.com

RF & Hyper Europe 2002
March 26-28, (Paris Expo Exhibition Center, Porte de Versailles, France)
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SiGe BiCMOS Yields 10-Gb/s 16:1 Multiplexer And Clock Synthesizer

HIGH-SPEED OPTICAL NETWORKS rely on several key components, including multiplexers and clock synthesizers. Recently, Hong-Ih Cong and a research team from Agere Systems (Murray Hill, NJ) developed an IC containing a 10-Gb/s 16:1 multiplexer, a 10-GHz clock generator PLL, along with a 6×16-b input data buffer by using 0.25-μm SiGe BiCMOS technology. The chip is designed for SONET/SDH optical-communications systems operating at a data rate of 9.953 Gb/s. The Tx chip works with parallel 16-b $\times$ 622-Mb/s low-voltage differential signal inputs and produces serial output data at 9.953 Gb/s along with a 9.953-GHz clock corresponding to the OC-192/STM-64 SONET/SDH optical-communications data rate. The Tx chip, which was designed for low-jitter performance, was also constructed to interface with a wide range of ASICs. For more information on this novel circuit, see "A 10-Gb/s 16:1 Multiplexer and 10-GHz Clock Synthesizer in 0.25-μm SiGe BiCMOS," *IEEE Journal of Solid-State Circuits,* December 2001, Vol. 36, No. 12, p. 1946.

Microstrip Antenna Array Tunes To LMDS Applications

LMDS APPLICATIONS HAVE been delayed to market due to the continuing high cost and difficulty of building components for use at millimeter-wave frequencies. But Soonsoo Oh and co-workers from Korea University (Seoul, Korea) have developed a practical broadband microstrip antenna array that is low in cost, light in weight, and well-suited for use in LMDS systems operating from 24.2 to 26.7 GHz. For more information, see "A Broadband Microstrip Antenna Array For LMDS Applications," *Microwave and Optical Technology Letters, Journal of Solid-State Circuits,* January 5, 2002, p. 35.

Router Delivers Bidirectional Signaling At Rates To 30 Gb/s

COMPUTER CLOCK SPEEDS have increased drastically during the last decade, although the interconnections used for linking the processor to other components have lagged behind. But Howard Wilson and Matthew Haycock of Intel Corp. (Hillsboro, OR) have developed a component capable of high-speed signaling to 30 Gb/s based on 0.18-μm CMOS technology. With enough bandwidth to support multiprocessor, high-bandwidth computer systems, their design demonstrates the feasibility of using high-speed point-to-point signaling techniques coupled with a simple high-bandwidth crossbar switch to create a scalable high-speed interconnect system. The crossbar switch uses a simple packet structure and routing protocol. The crossbar switch is fully nonblocking, allowing any input to be routed to any output simultaneously. If more than one input signal contends for the same output, arbitration occurs to determine the binding sequence for the inputs. Each physical link in the system is connected to four identical lanes referred to as "virtual channels." The lanes allow the physical links to accommodate data from four completely different packets simultaneously. The high-speed router features a bidirectional I/O cell and a linear driver that maintains a Thevenin output impedance while switching and closed-loop control to match the driver and Rx slew rates. For more information, see "A Six-Port 30-GB/s Nonblocking Router Component Using Point-to-Point Simultaneous Bidirectional Signaling for High-Bandwidth Interconnects," *IEEE Journal of Solid-State Circuits,* December 2001, Vol. 36, No. 12, p. 1954.

Apply Artificial Neural Network Techniques To RF/Microwave Measurements

ARTIFICIAL NEURAL NETWORKS offer tremendous potential for solving complex problems, including some microwave measurements. Jeffrey Jargon, K.C. Gupta, and Donald DeGroot of the RF Electronics Group of the National Institute of Standards and Technology (Boulder, CO) have experimented with a variety of ways in which artificial neural networks can be applied to model a variety of on-wafer and coaxial VNA calibrations, including OSLT and LRM calibrations. The authors describe how artificial neural networks can learn relationships among sets of input and output data. In the case of a VNA, the input vectors are computed, the artificial-neural-network outputs are compared to the desired outputs, and errors are calculated. Error derivatives are then calculated and summed for each weight, and artificial-neural-network training continues until errors are minimized. To learn more, see "Applications of Artificial Neural Networks to RF and Microwave Measurements," *International Journal of RF and Microwave Computer-Aided Engineering,* January 2002, Vol. 12, No. 12, p. 3.

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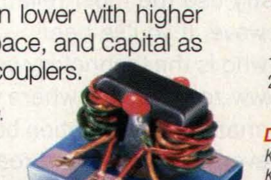

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10dB	DBTC-10-4-75	5-1000	1.4	20
12dB	DBTC-12-4	5-1000	0.7	21
13dB	DBTC-13-4	5-1000	0.7	18
13dB	DBTC-13-5-75	5-1000	1.0	19
		1000-1500	1.4	17
16dB	DBTC-16-5-75	5-1000	1.0	21
		1000-1500	1.3	19
17dB	DBTC-17-5	50-1000	0.9	20
		1000-1500	1.0	20
		1500-2000	1.1	14
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DESIGN

Constructing Circuits For Short-Range Radios

Builders of short-range radio links must pay attention to different performance requirements and cost issues when selecting a technology for a particular product design.

Short-range-radio designers generally do not share the resources available to the more standardized segments of wireless communications, such as cellular systems. For one thing, reference material on short-range radios is limited. To aid designers, Part 3 of this article series on short-range radios will review options for implementing short-range radios. The first two parts of this series have discussed system design issues (see *Microwaves & RF,* September 2001, p. 73) and regulations (see *Microwaves & RF,* October 2001, p. 79), respectively.

The lowest-cost option for short-range radio equipment is the classic inductive-capacitive (LC) link. This approach is acceptable in the US and other Federal Communications Commission (FCC)-based countries, but not in Europe with its tighter requirements for frequency accuracy. For European systems, surface-acoustic-wave (SAW) links are the lowest-cost systems that can generally meet those more stringent

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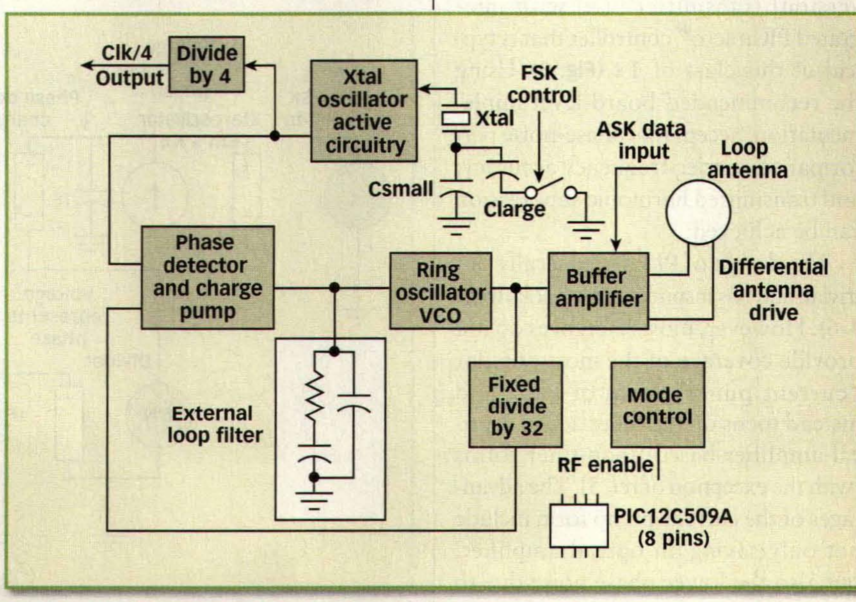
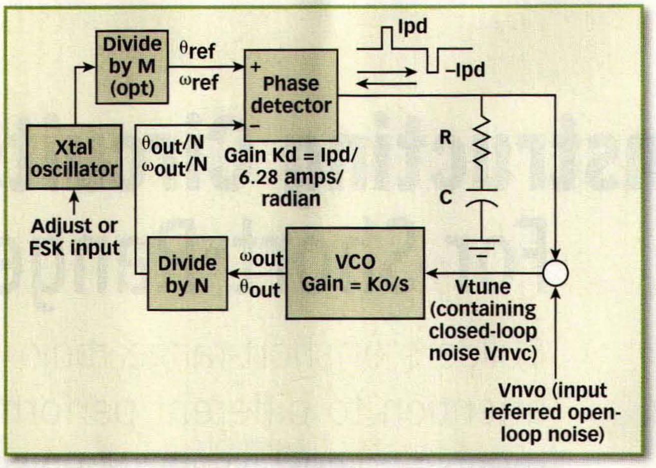


3. The model rfPIC12C509 is a PLL-based 310-to470-MHz short-range transmitter with integrated microcontroller.

requirements. The better frequency accuracy of SAWs compared to LC circuits supports narrower bandwidth receivers (Rxs) with improved sensitivity and interference immunity. This improved performance with good cost efficiency has led to SAWs being the method of choice over the last decade for wireless remote-keyless-entry (RKE) applications. However, within the last few years, integrated-circuit (IC) phase-locked-loop (PLL)-based systems have challenged SAWs in cost while providing an improvement in performance. This improvement is again partly based on better frequency accuracy, supporting narrower band and, thus, improved Rxs. Frequency synthesis also enables software-controlled frequency agility. The introduction of microprocessors into the links supports error control, transmit-power-level control, microcellular handoff, and a host of other features for more complex data-communications applications.

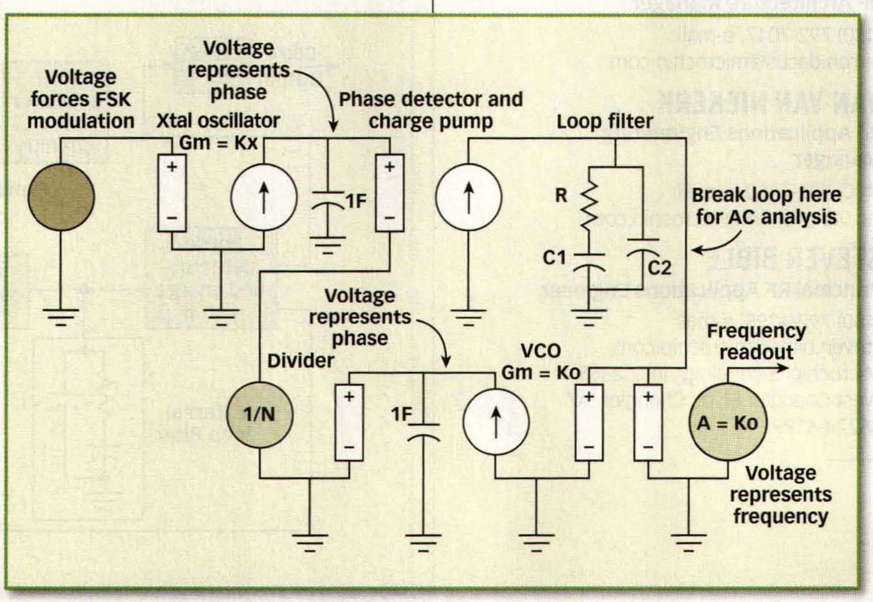


4. This block diagram shows a basic second-order charge-pump PLL.

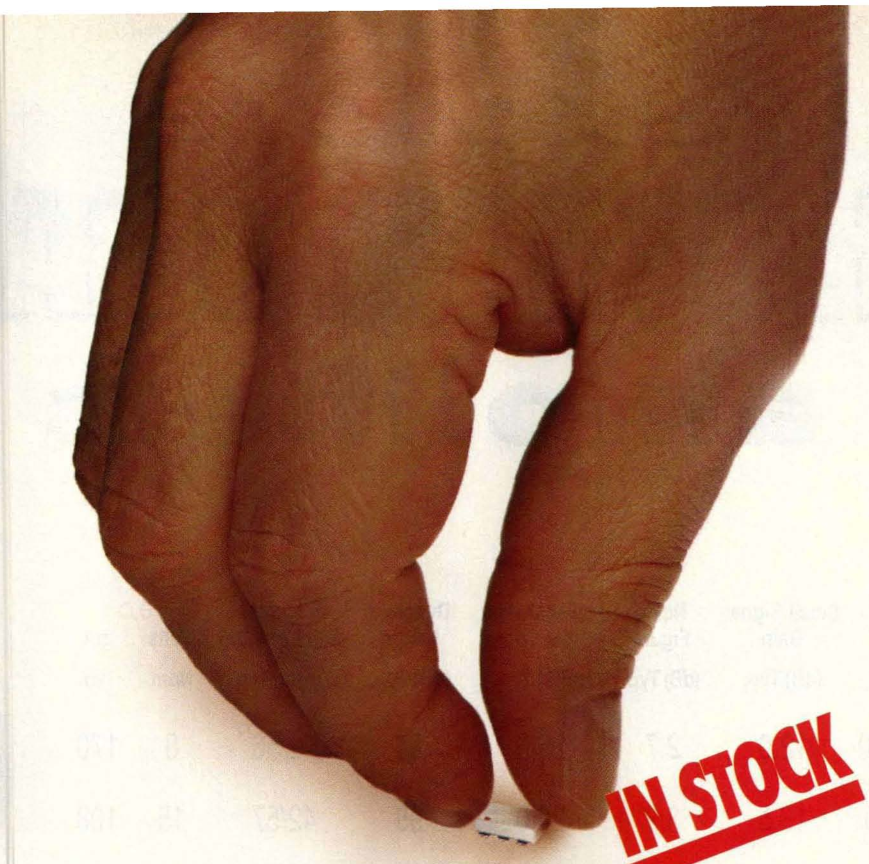
For example, the model rfPIC12C509 from Microchip Technology is a PLL amplitude-shift-keying (ASK) [18 pin SOIC 509AG version] and frequency-shift-keying (FSK) [20-pin SSOP 509AF version] transmitter (Tx) with integrated PICmicro® controller that is typical of this class of Tx **(Fig. 3)**. Using the recommended board-level implementation, acceptable phase-noise performance, carrier-frequency accuracy, and transmitted harmonic suppression can be achieved.

The design of PLLs is generally not trivial, and has inspired entire books (refs. 4-6). However, most references do not provide coverage of the most popular "current pump" form of PLL, and instead focus on the older active (optical-amplifier-based) loop-filter forms (with the exception of ref. 5). The advantages of the current-pump form include not only saving an optical amplifier, but also the lower phase noise due to the fact that the current pump is only on for a tiny fraction of the time in the locked state, thus greatly reducing flicker noise on the controlling input to the voltage-controlled oscillator (VCO), and, thus, limiting induced phase noise. Some short-range Tx ICs include the loop filter on the die and the customer need not understand or design a PLL. Others, such as that on the rfPIC12C509, provide more flexibility by using an off-die loop filter that a user can either design or take from an applications note. Of course, an RF IC designer must have a thorough understanding of the subject.

Since they are not commonly available, the design equations for current-pump PLLs have been collected here. They may be developed by applying standard control-system frequency-domain analysis, and the same basic methods will be used later in analyzing closed-loop noise. In applying this type of analysis to PLLs, the variations of voltage, frequency, and phase in the frequency domain are studied as small-signal variations around an operating point (the locked frequency). It may seem odd to view frequency and phase variations in the frequency domain, but it is perfectly valid. In this analysis, a VCO is viewed as an integrator of input voltage to output phase. This is also initially confusing, but it follows directly from the definition of radian frequency being the time derivative of phase. With these points in mind, the system is examined as a feedback-control system, which remains stable if the phase shift around the total loop is less than 360 deg. at all frequencies where the loop gain is greater than 1. It is also common for the simple analysis of PLLs to be put into what is known as "second-order normalized form." In this standard form, loop parameters may be more easily viewed and understood, and loop-component values can be calculated from



5. This basic closed-loop PLL SPICE model can be used for transient-response analysis.



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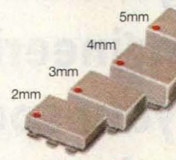

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ADEX-10L	+4	10-1000	7.2	60	16	3	2.95
ADE-1	+7	0.5-500	5.0	55	15	4	1.99▲
ADE-1ASK	+7	2-600	5.3	50	16	3	3.95
ADE-2ASK	+7	1-1000	5.4	45	12	3	4.25
ADE-6	+7	0.05-250	4.6	40	10	5	4.95
ADEX-10	+7	10-1000	6.8	60	16	3	2.95
ADE-12	+7	50-1000	7.0	35	17	2	2.95
ADE-4	+7	200-1000	6.8	53	15	3	4.25
ADE-14	+7	800-1000	7.4	32	17	2	3.25
ADE-901	+7	800-1000	5.9	32	13	3	2.95
ADE-5	+7	5-1500	6.6	40	15	3	3.45
ADE-5X	+7	5-1500	6.2	33	8	3	2.95
ADE-13	+7	50-1600	8.1	40	11	2	3.10
ADE-11X	+7	10-2000	7.1	36	9	3	1.99▲
ADE-20	+7	1500-2000	5.4	31	14	3	4.95
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ADE-3GL	+7	2100-2600	6.0	34	17	2	4.95
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ADE-28	+7	1500-2800	5.1	30	8	3	5.95
ADE-30	+7	200-3000	4.5	35	14	3	6.95
ADE-32	+7	2500-3200	5.4	29	15	3	6.95
ADE-35	+7	1600-3500	6.3	25	11	3	4.95
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ADE-30W	+7	300-4000	6.8	35	12	3	8.95
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ADE-12MH	+13	10-1200	6.3	45	22	3	6.45
ADE-25MH	+13	5-2500	6.9	34	18	3	6.95
ADE-35MH	+13	5-3500	6.9	33	18	3	9.95
ADE-42MH	+13	5-4200	7.5	29	17	3	14.95
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ADE-10H	+17	400-1000	7.0	39	30	3	7.95
ADE-12H	+17	500-1200	6.7	34	28	3	8.95
ADE-17H	+17	100-1700	7.2	36	25	3	8.95
ADE-20H	+17	1500-2000	5.2	29	24	3	8.95

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Table 4: Tuning curves for an IC VCO

FREQUENCY (MHz)	K_0 (MHz/V)
310	225
320	253
330	275
340	291
350	306
360	319
370	323
380	323
390	313
400	294
410	274
420	244
430	211
440	177.5
450	144.6
460	113.2
470	78.9

the desired loop parameters. The loop parameter of interest are the natural frequency, ω_n, and the damping factor, ξ. The natural frequency is the frequency at which the loop "rings" when settling. Though related to open-loop unity gain bandwidth, the two terms are not the same. The damping factor provides a measure of phase margin and stability. The loop is stable if $\xi > 0$, and it has the fastest settling time if $\xi = 0.707$. It does not noticeably ring if $\xi > 1$, but it does overshoot on step inputs since the phase margin is always less than 90 deg. Since extra filtering with additional phase shift is common in PLLs (this makes them higher than second order and thus not amenable to standard normalized form), a common design practice is to set $\xi = 1.0$ to 1.5 for hand calculation, and then adjust components in simulation to optimize phase margin, settling time, and spurious suppression. A simplified but usefully accurate Simulation Program with Integrated Circuit Emphasis (SPICE) model for higher-order PLL simulation will be shown for these simulations.

Figure 4 shows the block diagram of a suitable second-order current-pump PLL (for now, ignore the noise voltages V_{nvo} and V_{nvc} which will be used in a later noise analysis). It is suitable in that the sampling nature of the loop will be ignored, and the analysis performed using continuous variables. This is valid as long as the loop bandwidth is a very small fraction of the sample rate, but detailed simulation to determine actual phase shift is required when loop bandwidths are a significant (greater than a few percent) fraction of sample rate (reference frequency at the phase-detector input). The loop can maintain good stability with a loop bandwidth up to approximately 10 percent of the sample rate, though 5 percent is a safer number. The loop consists of a reference-frequency source, a VCO, a frequency divider, and a phase detector.

The reference-frequency source is almost always a crystal oscillator, which may be followed by an optional fixed or programmable divider of value "M." The purpose of the PLL is to force the VCO frequency to be some exact multiple of the reference frequency, thus transferring the high

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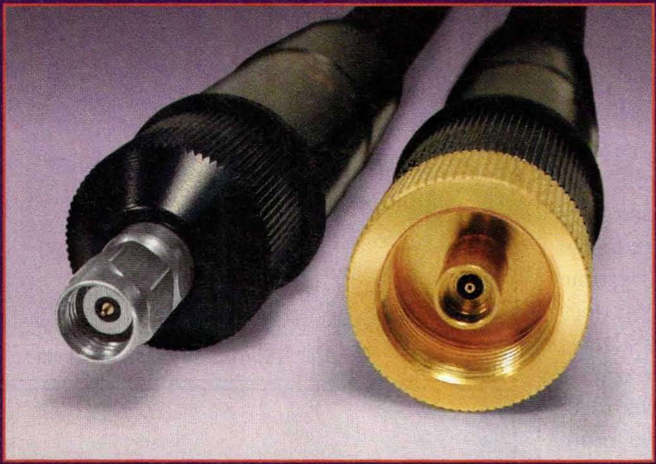

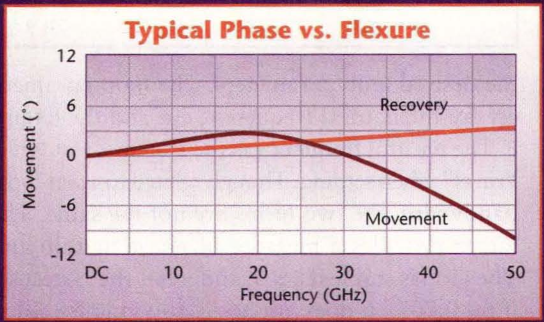

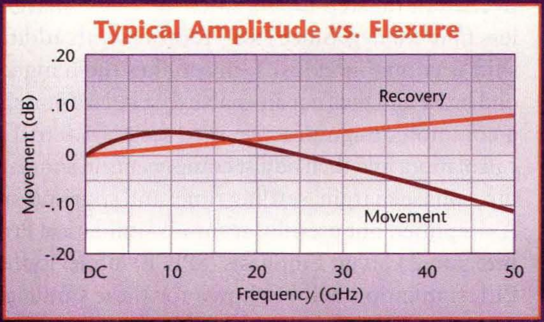

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accuracy and quality of the crystal oscillator to a frequency higher than that at which crystals may directly operate.

The VCO block converts an input "steering" or "tuning" voltage into an output frequency and phase. The VCO on the rfPIC12C509 is a relaxation oscillator, as opposed to the higher quality-factor (Q) LC or resonant oscillators that are common in standard radios. The high loop bandwidth supported by the fixed divider and high reference frequency suppress the "phase noise" of the low-quality free-running relaxation oscillator, thus allowing the use of a completely integrated VCO with limited performance. The "gain" of the VCO is normally referred to as K_0 and for PLL design normally has units of radians per second per volt (but often used in Hertz per volt form for noise calculations). Since the analysis is of phase variation and the VCO integrates input voltage to output phase (frequency offset from desired lock "integrates" into a phase error), the control-system frequency-domain transfer function of the VCO is K_0/s. Similar to most VCOs, the VCO in the rfPIC12C509 does not show perfect linearity. It varies over frequency **(Table 4)**, and this variation must be taken into account in the design of the PLL to ensure that desired loop parameters are achieved while stability and noise performance are maintained.

The digital frequency divider simply divides down the VCO frequency to match the reference frequency. In a frequency-agile synthesizer, this would be a programmable element. The divider reduces frequency and phase by its transfer function 1/N.

Phase Detector

The phase detector is almost always a digital subsystem that compares a reference frequency to the divided VCO output, producing a pulse width equal to the time difference between these signals. In the locked state there is no phase difference, so this width approaches zero. In the case of an active loop filter, the phase-detector output voltage directly drives the loop filter. For the current-pump case, the phase-detector output turns transistor-current sources on and off. These current pumps are then actually part of the phase detector, so that the current-pump phase-detector output is in current per radian of phase-error input. It is a sampled encoding but happens so quickly that continuous approximation is valid for basic analysis. The phase detector will provide a current, I_{pd}, for a time representative of up to 2π radians of phase error before the phase detector "rolls over" (runs out of encoding range by infringing into the next sample time). Its "gain" is therefore $K_d = I_{pd}/2\pi$ A/radian.

The loop filter takes the current pump output currents and, through filtering, suppresses their high-frequency content at the sampling rate and simultaneously converts the current back into a voltage to drive the VCO. A difference in the analysis of current pump versus optical-amplifier active loop-filter PLLs is that the active loop filter is a voltage-to-voltage transfer function, and the current-pump form is a current-to-voltage transfer function. The transfer function is simply the impedance of the loop filter, so since it is in its simplest form a series RC circuit in parallel with the phase-detector output, its transfer function is F(s) = (sRC + 1)/sC.

The phase transfer function of the loop is defined here as:

$$H(s) = (\theta_{out}/N)/\theta_{ref} \qquad (19)$$

where:

H(s) = the transfer function from the reference input on the phase detector to the feedback input.

$$H(s) = \left[\left(K_0 I_{pd} R\right)/(2\pi N)\right]s + \left[\left(K_0 I_{pd}\right)/(2\pi NC)\right]/\,s^2 + \left[\left(K_0 I_{pd} R\right)/(2\pi N)\right]s + \left[\left(K_0 I_{pd}\right)/(2\pi NC)\right] \qquad (20)$$

Table 5: Loop-filter values and loop parameters

R	C1 (pF)	C2 (pF)	FREQ. (MHZ)	K_0 (MHz/V)	LOOP BW	PHASE MARGIN	TRANSIENT OVERSHOOT	COMMENT
680	390	0	315	239	220 kHZ	73	31 percent	2nd order for reference Nat. frequency = 112 kHz Damping = 0.94
680	3900	390	315	239	190 kHZ	55	46 percent	Set up for U.S.
680	3900	680	315	239	175 kHZ	47	58 percent	
680	3900	1000	315	239	155 kHZ	39	76 percent	Note increasing overshoot with decreasing margin
680	3900	390	380	323	250 kHZ	54	45 percent	
680	3900	390	470	79	80 kHZ	45	67 percent	
1000	3900	0	434	198	260 kHZ	77	22 percent	Set up for European Last narrow BW
1000	3900	390	434	198	220 kHZ	52	40 percent	
7500	39	0	315	239	2.5 MHz	59	26 percent	Wide BW, nat. freq. = 1.13 MHz,-Damping = 1.03
7500	39	4.7	315	239	2.1 MHz	37	46 percent	
10K	39	0	434	198	2.85 MHz	57	20 percent	Nat. frequency. = 1 MHz, Damping = 1.25
10K	39	4.7	434	198	2.15 MHz	31	48 percent	
10K	39	4.7	434	198	2.15 MHz	31	0 percent	Square-wave modulation filtered with 100-kHz pole

This will turn out to be a lowpass function, and one that is highly indicative of loop locking, tracking, and noise behavior. From Fig. 3, the result of solving for this relationship is:

[SEE EQ. 20 ON PG. 66]

The standard normalized form of the second-order system is provided by:

[SEE EQ. 21 ABOVE]

$$H(s) = \left(2\varsigma\omega_n s + \omega_n^2\right) / \left(s^2 + 2\varsigma\omega_n s + \omega_n^2\right) \quad (21)$$

The two equations are in the same form, and by equating terms, the following analysis equations are obtained:

$$\omega_n = \left[\left(K_0 I_{pd}\right) / \left(2\pi NC\right)\right]^{0.5} \quad (22)$$

$$\varsigma = \left(K_0 I_{pd} R\right) / \left(4\pi N\omega_n\right) \quad (23)$$

Referring to Fig. 4, the common PLL error-transfer function is defined as:

$$H_e(s) = \left(\theta_{out} / N\right) / \theta_{ref} \quad (24)$$

Similar analysis shows that $H_e(s)$ may also be represented in normalized form as:

$$H_e(s) = s^2 / \left(s^2 + 2\varsigma\omega_n s + \omega_n^2\right) \quad (25)$$

where:

$H_e(s)$ = a highpass function.

However, the phase transfer function, H(s), is a lowpass function. It will turn out that many of the modulation and noise responses of PLLs can be conveniently expressed using these functions, which is a fact that is not highlighted in standard references.

From Eqs. 22 and 23, it is possible to obtain:

$$C = \left(K_0 I_{pd}\right) / \left(2\pi N\omega_n^2\right) \quad (26)$$

$$R = \left(4\pi N\omega_n\varsigma\right) / \left(K_0 I_{pd}\right) \quad (27)$$

Equations 26 and 27 are used to determine R and C based upon chosen values for the natural frequency and the damping factor. In practice, a second capacitor is normally added in parallel with the series RC of the suitable second-order loop filter, converting the loop to third order and adding additional phase shift.

The design equations for the basic second-order PLL model will provide a design that is close to the desired results. However, there are almost always additional poles in the loop that add phase shift that must be taken into account. A simple SPICE model is the easiest way to attack analysis of these effects and to obtain time-domain responses. **Figure 5** shows this model, where the sampling nature of the loop is neglected. The model is based on representing phase as voltage. The inte-

grating action of VCOs as integrators from input voltage to output phase is performed by current sources driving capacitors. To make this analogy mathematically correct, note that the output phase of a VCO is provided by:

[SEE EQ. 28]

The voltage on a capacitor driven by a voltage-controlled current source is:

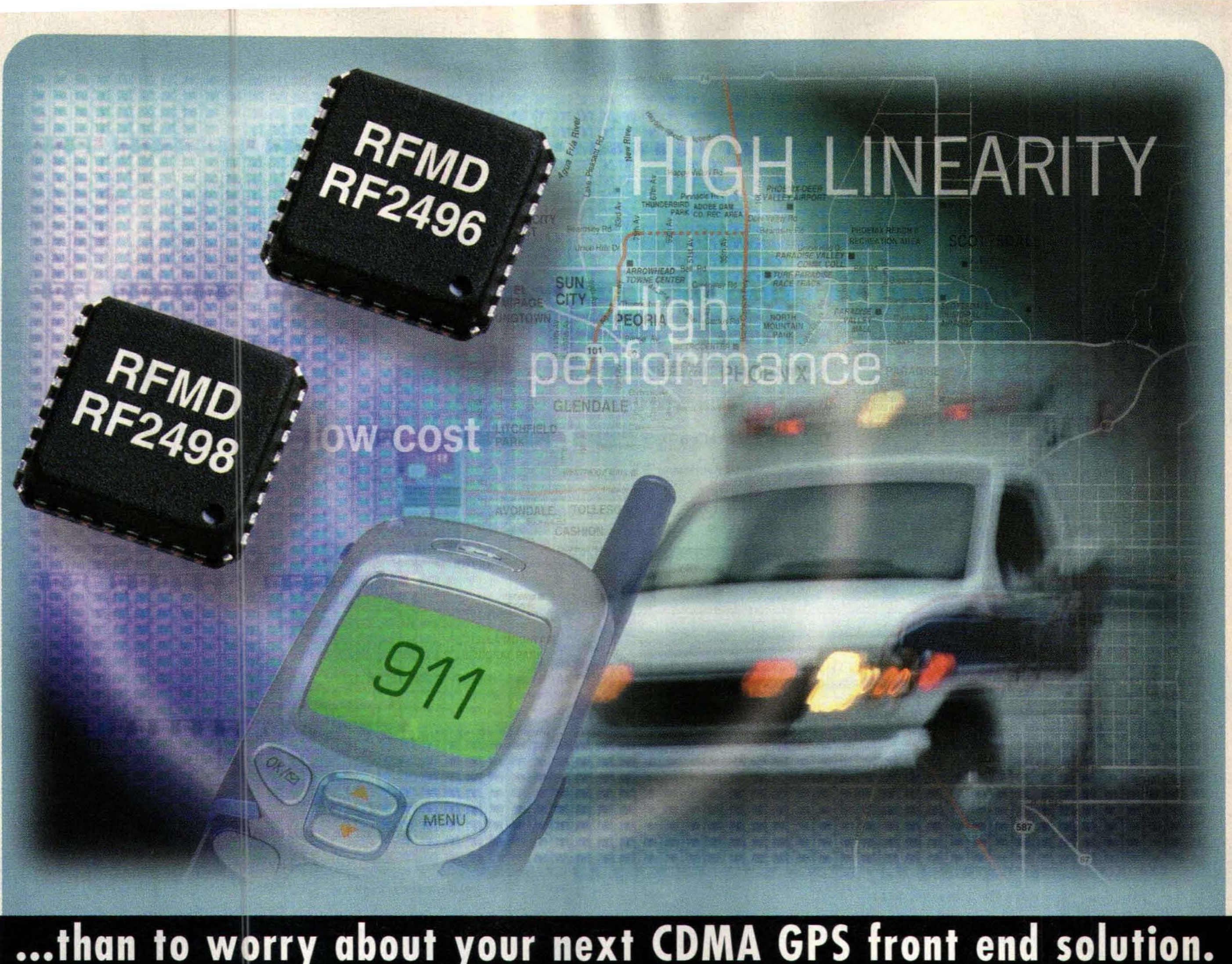
[SEE EQ. 29]

If the capacitance is 1 F, then by setting $g_m = K_0$,

$$\theta_{out}(t) = \int_0^t \omega(t)dt = K_0 \int_0^t V_{in}(t)\,dt \quad (28)$$

$$V_{out}(t) = (1/C)\int_0^t i(t)dt = (g_m/C)\int_0^t V_{in}(t)dt \quad (29)$$

the VCO may be replaced with the current source driving a capacitor, with output voltage numerically equal to VCO phase. This has been performed in Fig. 5 with two such integrators representing a voltage-controlled-crystal-oscillator (VCXO) reference and the VCO. The current pump uses the actual value the chip provides (260 µA in the case of the rfPIC12C509), and the divider is represented as the fraction used (1/32 in the case of the rfPIC12C509). Since the bandwidth of this PLL type usually exceeds 100 kHz, it can track crystal-oscillator frequency variations to the limit that the crystal can be modulated. In the rfPIC12C509 the crystal is modulated by varying the capacitance in series with the crystal. This effect is modeled in Fig. 5 by a voltage-driven VCXO. If the crystal oscillator is pushed near the limit of its modulation bandwidth (approximately 10 to 15 kHz), then its response to modulation is complex, though basically low-pass and thus amenable to modeling using filtering preceding the VCXO block of Fig. 5. The crystal oscillator of the rfPIC12C509 can typically be modulated up through 20 kb/s. Since loop filters are typically designed to support PLL operation for noise and lock time, and not for response to FSK modulation of the PLL, some modifications of typical design parameters are called for in setting up the PLL for FSK modulation. Generally, a larger-than-normal damping factor (more phase margin than the typical 45 deg.) is used. This Tx also provides for ASK modulation through turning the power amplifier (PA) on and off, in which case the standard choices for damping factor and phase margin apply. Generally for ASK a damping factor of 0.7 (45 deg. of phase margin) will provide the fastest settling time while providing acceptable tran-



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Gain (dB)*	26	25 (Cell)/26 (PCS)	25 (Cell)/25 (PCS)	23/25 (Cell)/26 (PCS)/34 (GPS)
Noise Figure (dB)*	2.4	2.1 (Cell)/2.2 (PCS)	1.9 (Cell)/2.2 (PCS)	2.0/1.8 (Cell)/2.1 (PCS)/1.8 (GPS)
IIP3 (dBm)	+9 (LNA)	+11 (Cell LNA) +8 (PCS LNA)	-9.0 (Cell)/-8.5 (PCS) Cascaded results for RX path	+11 (Cell LNA)/+8 (PCS LNA)/ +3 (GPS LNA)
Package	4x4mm LCC	5x5mm LCC	8x8mm module	5x5mm LCC
Technology	SiGe HBT	SiGe HBT	SiGe HBT	SiGe HBT
Application	Cell CDMA AMPS	Cell/PCS CDMA AMPS	Cell/PCS CDMA AMPS	Cell/PCS CDMA AMPS GPS

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sient response and minimum lock time (approximately $2/f_n$, where f_n is the natural frequency).

Using the SPICE model, a set of values for loop filters were generated for the rfPIC12C509 **(Table 5)**. Some interesting trends may be observed here. First, the significant difference between loop bandwidth as defined by the open-loop unity-gain crossover and the natural frequency as observed in common PLL design is evident. The loop bandwidth is typically several times the natural frequency, and unlike the natural frequency, the loop bandwidth is not independent of the damping factor. However, as the damping factor approaches zero (as loop-resistor R approaches zero), the loop bandwidth will approach the natural frequency. The damping resistor pushes the loop bandwidth higher because the charge-pump current flowing through it induces a greater voltage as R increases, and, thus, greater loop gain. The additional capacitor (C2) necessary to suppress synthesizer spurious offset from the carrier by the loop sample rate pushes loop bandwidth and phase margin back down.

FSK Modulation

FSK modulation within a PLL can be provided by several methods. The simplest practical method that can provide modulation down to DC is to modulate the reference, as is performed with the rfPIC12C509. In this IC, FSK modulation is implemented by keying a capacitor in series with the crystal, so it is shaped only by the natural response of the crystal (to be covered in detail in Part 5 of this article series). The wideband PLL then follows this modulation, which is easily performed since it is so much wider than the data bandwidth that the crystal will support (20 kb/s). However, the PLL will generate undesired overshoot with step modulation. The data in Table 5 shows that a decrease in loop-phase margin will increase the overshoot of the VCO frequency output. Overshoots to 50 percent of peak FSK are common if steps are not taken to control it. The primary step taken by the user of this part is to maintain the greatest phase margin consistent with meeting spurious requirements (see the previous part of this article series). This is aided by the fact that the crystal response cannot actually make a sharp step. It is a complex lowpass filter function that does not exhibit an instant transition. The last row in Table 5 shows the large difference in step response that occurs when the modulating signal is even lightly filtered, as long as the filtering is well-below the loop bandwidth. In that row, FSK occurs at 10 kb/s, and is filtered with a first-order lowpass filter with pole at 100 kHz with a loop bandwidth of 2.15 MHz. The loop is so fast that it tracks the changing reference almost perfectly, and, hence, does not overshoot. This mild filtering, which is built into the crystal, accounts for the difference between severe overshoot of 48 percent of peak value and overshoot of less than 1 percent.

Analytically, it may be easily shown that the transfer function from reference-frequency input to VCO fre-

quency output is also provided by the phase-transfer function of Eq. 21. If the frequency response of the crystal to a modulating input is $V_m(s)$, then the transfer function from $V_m(s)$ to the VCO output frequency is provided by:

$$\omega_{out}(s) = V_m(s)X(s)H(s) \quad (30)$$

Response $V_m(s)$ may be replaced with another signal type, such as the step-function-modulated capacitance used in the rfPIC12C509. Transfer function X(s) may be crudely modeled as a first-order lowpass response, and simulations will show that this will greatly reduce the overshoot of the FSK as long as the loop bandwidth exceeds the crystal-modulation bandwidth.

Phase-Noise Control

Phase-noise control in VCOs is a subject that has been well-covered in previous work, but there are some new twists with respect to short-range radios. Phase noise is a particular problem in short-range radio because phase-noise performance is not specified in standards, and due to the low power consumption and low Q of integrated VCOs. Some of these VCOs do not use bandpass resonators, and are effectively relaxation oscillators with a bandwidth from DC to beyond the oscillation frequency. Their Q is approximately 1, as opposed to the loaded Q of 10 to 50 that could be attained with an LC oscillator. Since phase noise is inversely proportional to Q^2, the phase noise of these oscillators is particularly poor. This problem is typically dealt with by use of a wide-bandwidth PLL, which suppresses close-in phase noise to approach the multiplied phase noise of the crystal-reference oscillator. This also suppresses phase noise induced by other sources, such as flicker and digital noise on the power supply of the VCO and PLL. How wide must the PLL loop bandwidth be? A procedure to answer this critical question will be provided next month in the fourth part of this article series on short-range radio design.

Next month, Part 4 of this series will compare the phase-noise characteristics of different frequency sources, including a crystal oscillator, a free-running VCO, and a phase-locked VCO. A phase-noise analysis will be provided to understand the effects of noise on receiver bit-error-rate (BER) performance for different data formats. MRF

REFERENCES

4. R. Best, *Phase Locked Loops*, 3rd ed., McGraw-Hill, 1997.
5. D. Banerjee, *PLL Performance, Simulation, and Design*, 2001.
6. Ulrich Rohde, *Digital PLL Frequency Synthesizers*, 1983.

Design NMR Probes At High Frequencies

Simulations of NMR probes at discrete frequencies show that the quality coefficient of the shielded-band resonator is better than that of the split-ring resonator.

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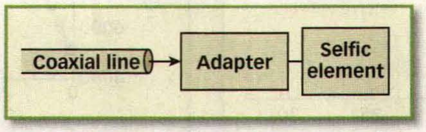
Nuclear-magnetic-resonance (NMR) probes are vital to materials research and medical applications. With the capability of being easy to fabricate, a symmetrical-band resonator is flexible enough to adapt to a different range of sizes at a particular frequency. The full design of an NMR probe using the symmetrical-band resonator, which has a high quality factor (Q) in the 200-to-2000-MHz range, will be presented in this article. Symmetrical-band resonator parameters are calculated with respect to the geometrical parameters by the finite-element method (FEM). The modelization results of NMR probes using the symmetrical-band resonator at 500 MHz, 1 GHz, and 2 GHz, show that the quality coefficient of the shielded symmetrical-band resonator is better than that of the split-ring resonator.

The frequency region above 200 MHz and below 2 GHz represents a difficult problem for high-sensitivity magnetic resonance. A standard cavity resonator cannot be used because its RF field is inhomogeneous. Capacitively tuned solenoidal coils, which are good choices for frequencies up to 100 MHz, become impractical at higher frequencies because they become self-resonant.[1-3]

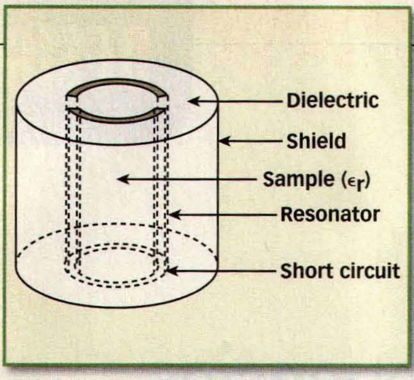


1. The NMR probe is a resonant circuit that consists of a selfic element and other components that are used with the adapter.

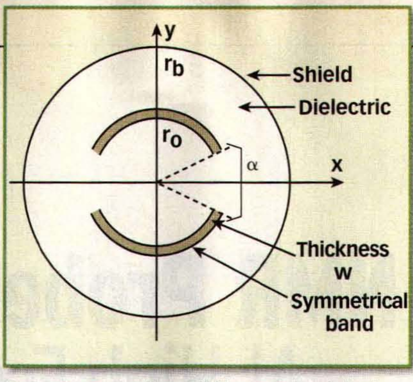
Hardy and Whitehead[4] have developed a shielded split-ring resonator with a very-high Q and excellent field homogeneity. Beginning with this structure, it is suggested that another type of resonator be constituted from a shielded symmetrical-band resonator. The shielded symmetrical-band resonator is easy to fabricate and, for a particular frequency, can be used for different sizes.

The shielded symmetrical-band resonator has a higher Q than the shielded split-ring resonator, according to some geometrical conditions.

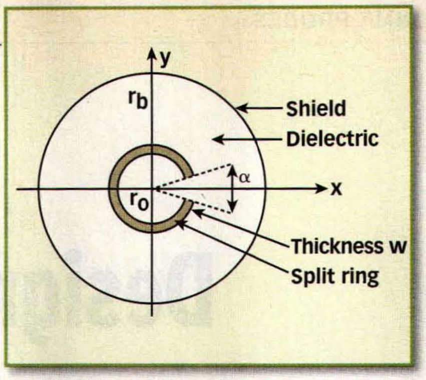
An analytical solution using conformal transformations has been provided by Schneider[3] for a structure constituted by only two conductors. He assumes that the shield is placed very far from the selfic element. Therefore, he has accounted for the non-negligible influence of the shield. Unlike Schneider's study, this one takes the influence of the shield into account and the presence of the odd and even modes in the structure, which are composed of three conductors (the bands and the shield). Consequently, the structure has two characteristic impedances associated



2. This is a detailed illustration of the shielded symmetrical-band resonator.



3. A cross-section of the symmetrical-band resonator can be seen here.



4. This figure shows the cross-section of the shielded split-ring resonator.

with these modes. To resolve the problem, an FEM-based numerical tool was applied.

Many NMR experiments involving very-high homogeneity and high power required the redefinition of the probe. To study a sample, the probe must transmit RF energy and convert it to magnetic energy. The probe is a resonant circuit with a selfic element (e.g., solenoid or symmetrical-band line) and other components used for the adapter **(Fig. 1)**. The selfic element has a fundamental role in the spectrometer. This resonator must have high Q and good magnetic-field homogeneity.

The symmetrical band is a section of line that is short-circuited at one extremity and opened at the other. This element has the role of self-inductance. To avoid all electromagnetic (EM) coupling between the symmetrical band and the other spectrometer circuits, it should be shielded **(Fig. 2)**.[2] An analytical solution[1] for the EM fields of the structure, shown in Fig. 2, is difficult to realize because the resonator has an open contour **(Fig. 3)**.

The structure shown in Fig. 3 is based on the resolution of the Laplace's equation in two dimensions (2D) for the even and odd modes.

$$div\left[\varepsilon_r \nabla_t V(x, y)\right] = 0 \qquad (1)$$

where, for the even mode:

V = 1V on the two conductors.

V = 0 on the shield.

and for the odd mode,

V = 1V on one conductor.

V = −1V on the other conductor.

V = 0 on the shield.

A solution can be found by using the FEM method.[1] This solution represents the distribution of the potential V in the structure. When V is known, the even- and odd-mode characteristic impedances can be calculated.

Lossless-line theory makes it possible to determine the electrical field, the magnetic field, and the electrical energy W_{em} accumulated in the structure from the potential V. All of the characteristic impedances can then be deduced easily from the electrical energy W_{em}. Consequently, it is important to determine potential V with high precision.[5]

• The electrical field is deduced by simple derivation from the potential V by:

$$\vec{E}_t = -\nabla_t V(x, y) \qquad (2)$$

where:

t = the cross-section of the structure.

The structure accumulates an electrical energy which is deduced from the electrical field by:

$$\overline{W}_{em} = \frac{1}{4}\iint \varepsilon_0 \varepsilon_r \vec{E}_t \vec{E}_t^* dxdy \qquad (3)$$

where:

* = the conjugate vector.

The capacity per unit length is deduced directly from the electrical energy.

$$C = \frac{4\overline{W}_{em}}{\left(V_1 - V_2\right)^2} (F/m) \qquad (4)$$

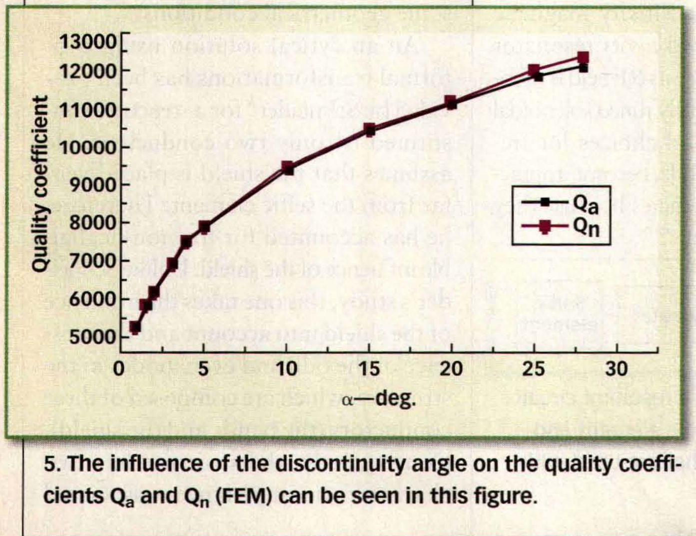
where:

V_1 and V_2 = the fixed potential on the conductors.

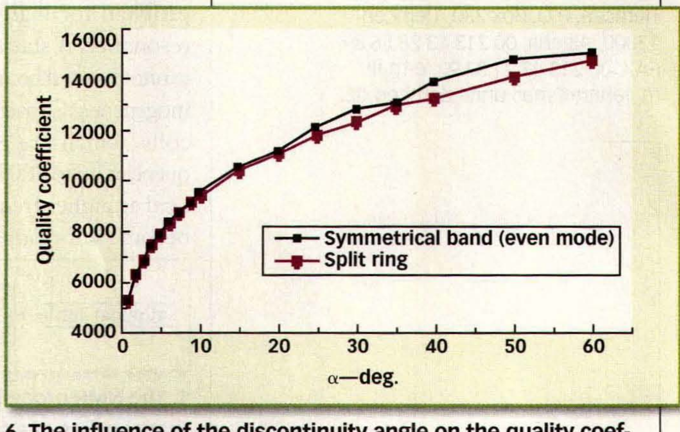
The characteristic impedance can be calculated from the following relation:

$$Zc = \frac{1}{v_\phi C} \; (\Omega) \qquad (5)$$

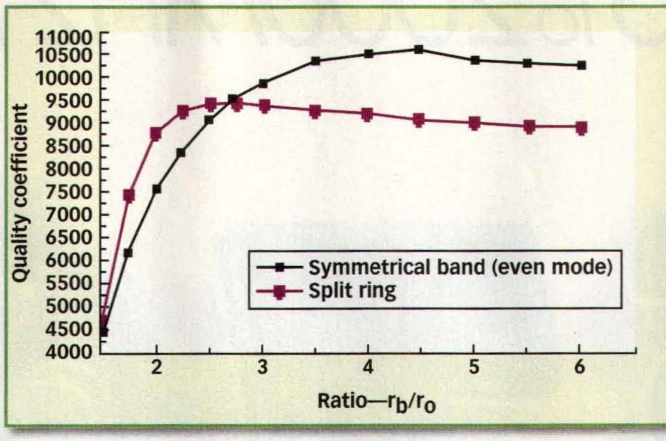
where:



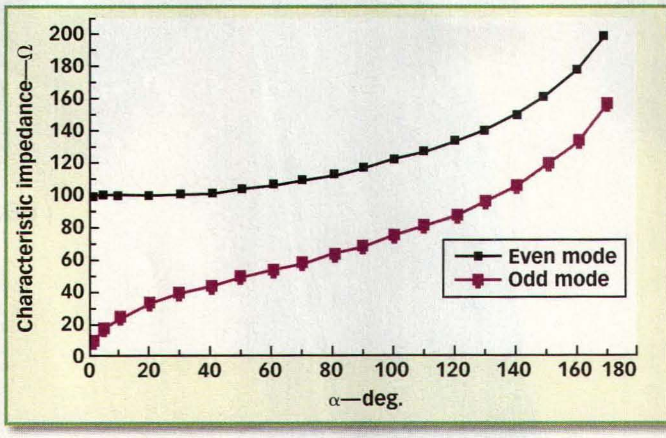
5. The influence of the discontinuity angle on the quality coefficients Q_a and Q_n (FEM) can be seen in this figure.



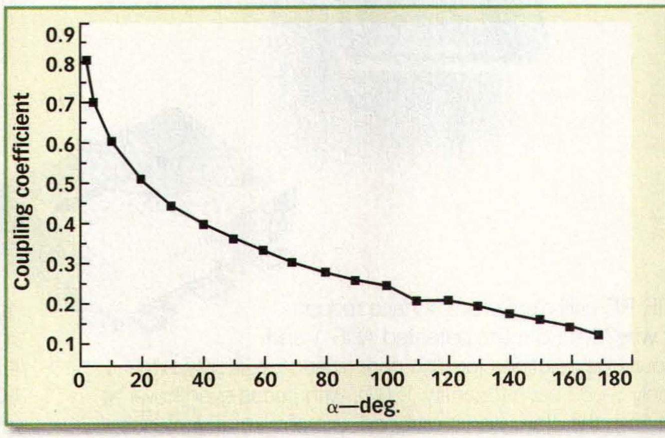
6. The influence of the discontinuity angle on the quality coefficient of the shielded symmetrical-band resonator and the shielded split-ring resonator is shown here.



7. The influence of the discontinuity angle on the quality coefficient of the shielded symmetrical band and the shielded split-ring resonators is illustrated in this graph.



8. The dependence of the discontinuity angle on even- and odd-mode characteristic impedances is presented here.



9. This graph shows the influence of the discontinuity angle on the coupling coefficient.

$$v_\phi = \frac{3.10^8}{\sqrt{\varepsilon_r}} \ (m/s) \qquad (6)$$

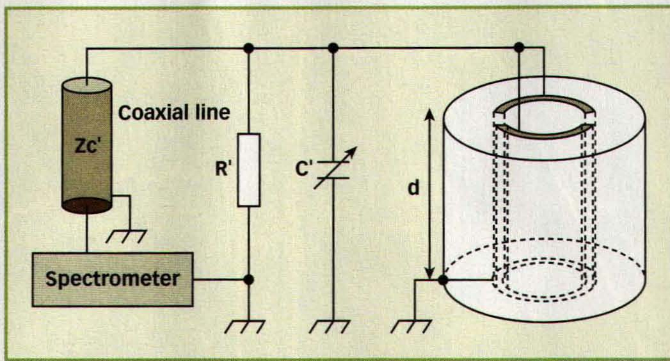
The inductance per unit length is provided by:

$$L = Zc^2\ C\ (H/m) \qquad (7)$$

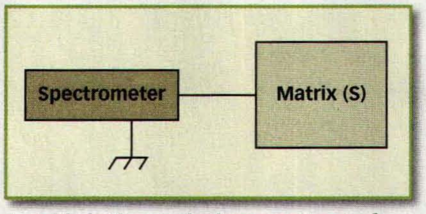
When the even- and odd-mode characteristic impedances (Z_{oe}, Z_{oo}) are known, the coupling coefficient k, using the following relation, can be calculated:

$$k = \frac{Z_{oe} - Z_{oo}}{Z_{oe} + Z_{oo}} \qquad (8)$$

The resistance per unit length can be calculated from the power dissipated by the Joule effect in the symmetrical band and in its shield.



10. An NMR probe uses the shielded symmetrical-band resonator.



11. This is the equivalent montage of the NMR probe.

Consider the i^{eme} conductor of the shielded symmetrical-band line, with σ_i as its conductivity and $Rs_i = (\omega\mu/2\sigma_i)^{0.5}$ as its superficial resistance.

The conductor's section dz will dissipate the power:

$$dP_i = \frac{1}{2} Rs_i dz \int_{\Gamma_i} |Is_i|^2 dS =$$

$$\frac{Rs_i}{2\eta^2} dz \int_{\Gamma_i} \left(\frac{\partial V}{\partial n}\right)^2 dS \qquad (9)$$

where:

Γ_i = the contour of the i^{eme} conductor,

$\partial v/\partial n$ = the outside normal derivative to Γ_i, and

η = the wave impedance.

Evaluate the power dissipated in the symmetrical band and its shield by:

$$dP = dP_1 + dP_2$$

where:

dP_1 = the power dissipated by the symmetrical band, and

dP_2 = the power dissipated by the shield.

The resistance per unit length of the shielded symmetrical band will be:

$$R = 2\frac{dP}{dz}\frac{1}{I^2} \quad (\Omega/m) \qquad (10)$$

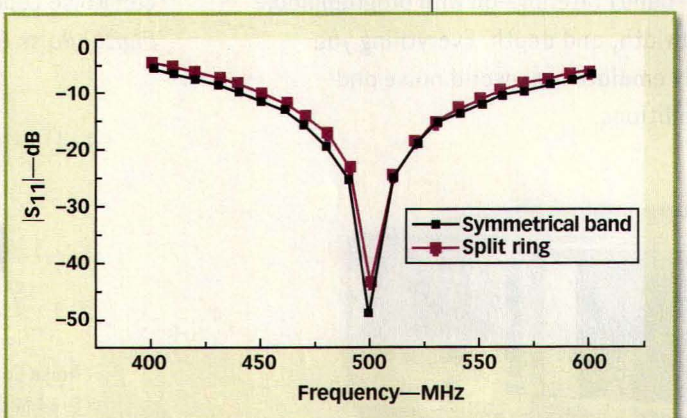
The Q can be deduced from the relation in Eq. 11:

$$Q = \omega \frac{\frac{1}{2}LI^2}{\frac{1}{2}RI^2} = \frac{L\omega}{R} \qquad (11)$$

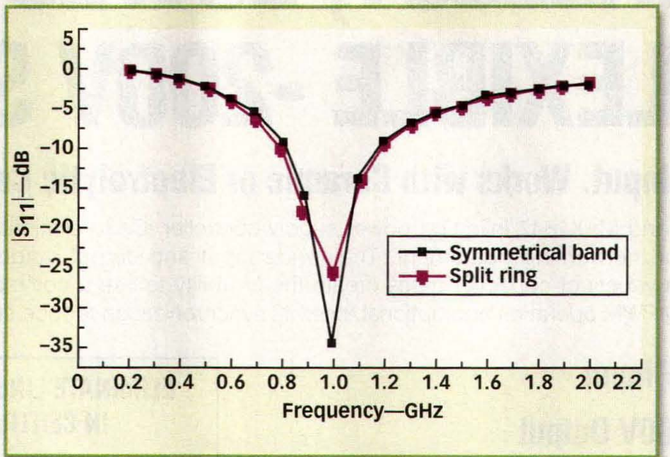
The coupling capacity, γ, and the mutual inductance, M, can be deduced from the coupling coefficient k:

$$k = \frac{\gamma}{C_0} = \frac{M}{L} \qquad (12)$$

Eq. 12 allows one to determine the matrices L, C, R, and G using the following formulas:



12. The influence of the frequency on the reflection coefficient at the input of the probes at 500 MHz is seen here.



13. The influence of the frequency on the reflection coefficient at the input of the probe is illustrated here at 1 GHz.

$$[L]=\begin{bmatrix}L & M\\ M & L\end{bmatrix},\ [C]=\begin{bmatrix}C_o+\gamma & -\gamma\\ -\gamma & C_o+\gamma\end{bmatrix}$$

$$[R]=\begin{bmatrix}R & 0\\ 0 & R\end{bmatrix},\ [G]=\begin{bmatrix}G & 0\\ 0 & G\end{bmatrix} \qquad (13)$$

L, Co, R, and G are the isolated line parameters obtained by FEM.

Based on previous theory, a computer-aided-design (CAD) program was established to calculate the coupling coefficient and the matrices L, C, R, and G of the shielded symmetrical-band resonator. Every parameter is strongly dependent of the resonator features and properties of the sample.

The flexibility of the developed CAD supports CAD testing with the split-ring resonator. This resonator **(Fig. 4)** constitutes a good reference because some approached analytical parameters in the literature are disposed of.[4]

Based on Fig. 4, the following can be defined:

α = the discontinuity angle of the split-ring resonator.

For $r_o = 20$ mm, $r_b = 2.75r_o$, $w = 4$ mm, $\epsilon_r = 1$, and $f_o = 570$ MHz, the results shown in **Fig. 5** were obtained.

The variations of the quality coefficient Q_n, calculated by the FEM, and Q_a, calculated analytically by Hardy and Whitehead in function of the discontinuity angle, α, are in very good agreement. The difference observed between Q_n and Q_a for the higher value of α is the consequence of the approximation of the analytical solution.

The tests applied to the software are successful.[1,5] The influence of the discontinuity angle on the quality coefficient of the shielded symmetrical-band resonator (Fig. 3) and the shielded split-ring resonator (Fig. 4) is seen in **Fig. 6**.

It appears that the shielded symmetrical-band resonator presents a higher-quality coefficient for a discontinuity angle $\alpha > 5°$ than the shielded split-ring resonator. This is a particular specification of the shielded symmetrical-band resonator compared to the shielded split-ring resonator.

The influence of the shield position on the quality coefficient is shown in **Fig. 7**, where if $r_b > 2.75r_o$, the quality coefficient of the shielded symmetrical-band resonator is better than that of the shielded split-ring resonator. One can then conclude that for $\alpha > 5°$ and $r_b > 2.75r_o$, the shielded symmetrical-band resonator is well-adapted to realize powerful NMR probes.

In **Fig. 8**, the dependence of the discontinuity angle on even- and odd-mode characteristic impedances can be seen. **Figure 9** shows the influence of the discontinuity angle on the coupling coefficient.

A numerical tool has been developed to design NMR probes through a description of its components. This simulation allows one to decide if the constraints permit the realization of the probe.

The NMR probe in **Fig. 10** consists of the buckle of current, which contains the sample; the components of according and adaptation, which are coupled to the buckle of current; and the coaxial line, which excites the resonant circuit and all constituents of the probe.[1]

(Continued on page 103)

Simulate An I/Q Modulator

Using a powerful suite of software tools, it is possible to efficiently simulate the performance of a direct-conversion I/Q transistor-level modulator.

In-phase/quadrature (I/Q) modulators are invaluable components in modern digitally modulated communications systems. Also known as vector modulators, they operate by taking two baseband data sequences (the I and Q channels) and varying the amplitude and phase of a sinusoidal carrier signal in response to the instantaneous I and Q channel voltage.[1,2] Designers of these integrated circuits (ICs) must

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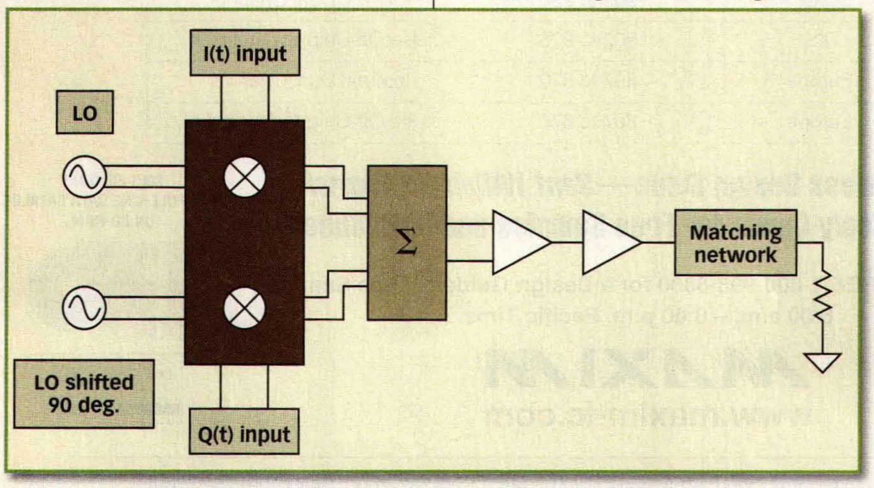
be concerned with several performance characteristics, such as modulation accuracy, dynamic range, frequency response, undesired leakage, and intermodulation distortion (IMD), as well as power consumption, efficiency, and output power. But with the help of a computer-simulation tool, such as the Advanced Design Systems 2001 (ADS 2001) from Agilent Technologies (Santa Rosa, CA),[3] it is possible to model an I/Q modulator in software prior to fabricating the IC.

What follows is an example of a computer-simulated direct-conversion, transistor-level I/Q modulator using the ADS 2001 system. The circuit includes differential-mode mixers, along with a combiner, buffer, and power amplifier (PA). To illustrate the design process, many simulations of subcircuits and of the entire modulator will be provided on the long version of this article (available on the *Microwaves & RF* website at www.mwrf.com).

The specific design is for a direct-conversion I/Q modulator (**Fig. 1**). Two 960-MHz local-oscillator (LO) signals with a 90-deg. phase difference are directly modulated by differential-mode baseband I and Q data signals. In this example, suitable LO signals are generated by the simulator, although simulations are included with amplitude and phase imbalances to see their effects. Some designers might choose to include a 90-deg. phase shifter, often implemented with an resistive-capacitive/capacitive-resistive (RC/CR) network.

A number of simulations were run



1. The modulator consists of a mixer, combiner, differential-input buffer, and power amplifier.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Carrier: 820.00E+6 Hz
Low cost
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on each of the parts of the modulator, as well as simulations with the parts combined together. Simulations of each part of the modulator include analysis of the amplifier, the differential input to single-ended output converter, the mixers, and the combiner circuitry.

The low-power amplifier converts a voltage source input into a current, which is required to drive an off-chip large-signal amplifier when higher output power is desired. The topology consists of an emitter-follower stage driving three emitter followers in parallel.

Simulation of the DC input-output transfer curve of the amplifier helps select the best bias voltage for the input signal, to discover the maximum dynamic range without clipping. This will not provide maximum efficiency, but for modulation formats, such as amplitude and phase, minimizing distortion may be more important than DC power consumption.

A load-pull simulation was run to evaluate the output power, DC-to-RF efficiency, and third- and fifth-order IMD versus load impedance at one bias point. In this simulation, a circular region of the Smith chart is specified, with load impedances within this region presented to the output of the amplifier. The DC-to-RF efficiency can be increased somewhat by driving the amplifier with a larger input signal, at the expense of increased distortion.

After running the load-pull simulation, the ADS Power Amplifier DesignGuide was used to determine component values for a simple series-L, shunt-C, series-C matching network to generate the desired load impedance at 960 MHz. Then a swept amplitude simulation was run to check output-power compression, as well as IMD and output waveforms versus input signal amplitude.

As an additional characterization test, a one-tone simulation was run with a sweep of two parameters. The first was the emitter resistor in each of the three parallel output stages, which sets the bias current. The other was the input bias voltage. The results of this simulation show that there are tradeoffs that can be made between output power, DC-to-RF power efficiency, and DC bias-current consumption.

The differential input to single-ended output converter is required because the baseband circuits handle differential-mode signals while the output amplifier is single-ended. The simulations of this circuit include the DC transfer characteristic, plus the differential- and common-mode small-signal gains and the common-mode rejection ratio versus frequency.

Simulations of the combiner include the DC transfer characteristic, as well

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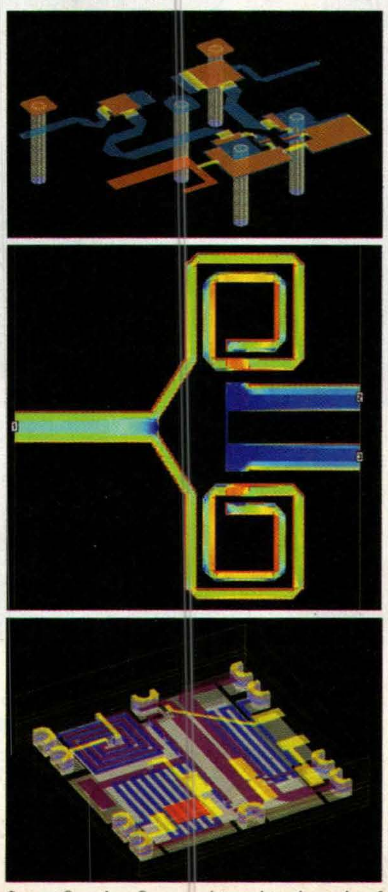

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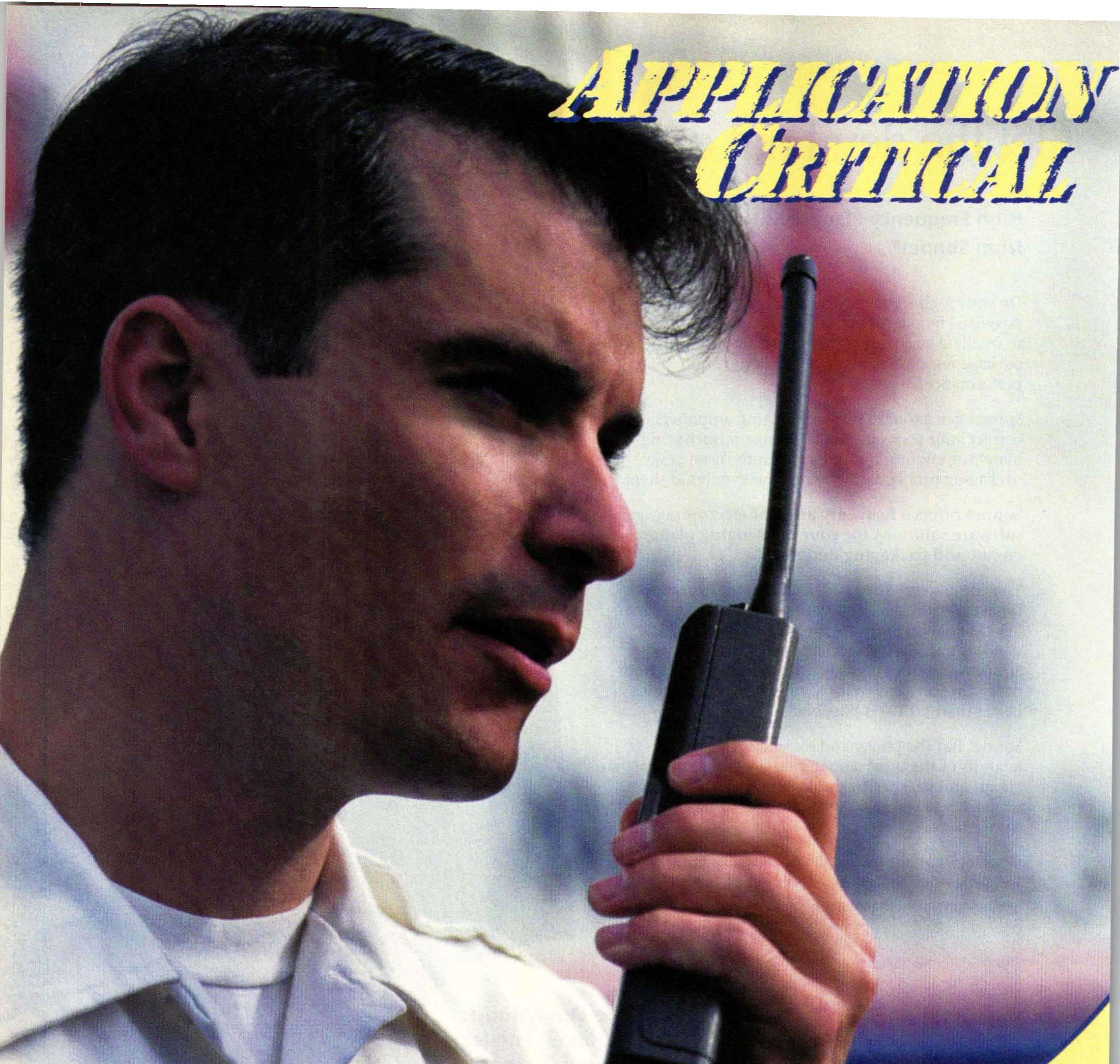

APPLICATION
CRITICAL

as the differential- and common-mode small-signal gains and the common-mode rejection ratio versus frequency. Two differential-mode mixers, similar to Gilbert cells, are used to modulate the two LO signals in quadrature with the baseband I and Q waveforms.

Since they perform frequency conversion, characterizing mixer performance is more complex than it is with circuits such as amplifiers. The first characterization is the conversion gain, plus second- and third-order IMD versus baseband signal amplitude. In this simulation, the LO signal, modeled as a pulse waveform, is set to 960 MHz. Two baseband signals are defined, spaced 20 kHz apart and centered at 1 MHz, although these frequencies may be set arbitrarily without affecting simulation performance, which is not possible with some time-domain simulators.

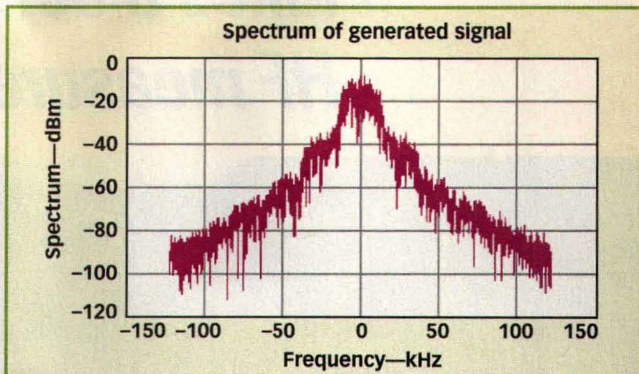
Finally, the modulator was simulated with baseband signals corresponding to various modulation formats, such as $\pi/4$ differential-quadrature phase-shift keying (DQPSK) and code-division multiple access (CDMA) [**Fig. 2**]. To download the ADS 2001 example used in this article, visit www.agilent.com/eesof-eda. MRF

REFERENCES

1. Jim Wholey "Vector Modulator IC's for Use in Wireless Communications," *Proceedings of RF Expo West*, 1993, pp. 232-240.

2. "Digital Modulation in Communication Systems—An Introduction," Hewlett-Packard Application Note 1298, 1997.

3. The ADS I/Q modulator example discussed in this article may downloaded from The Agilent website: http://contact.tm.agilent. com/tmo/eesof/applications/latest.html. The file name is IQ_Mod_from_ MDS_prj.zap.



MainChannelPower_dBm
6.024

Lower channel ACPR	Upper channel ACPR
TransACPR(1)	TransACPR(2)
–22.574	–21.761

2. This plot shows the modulator output spectrum, output power, and adjacent-channel power levels, with baseband I and Q signals corresponding to the NADC $\pi/4$ DQPSK modulation format.

DESIGN

Microwave Software Eases PA Combiner/Divider Design

A design automation package handles a MMIC RF PA's combiner and coupler designs from start to finish.

When it became necessary to convert one of the company's standard RF power amplifiers (PAs) from a discrete-matched gallium-arsenide (GaAs) field-effect-transistor (FET) design to a monolithic-microwave-integrated-circuit (MMIC)-based one, the key criteria behind the topology of the combiner assembly was low loss and manufacturability. Particular attention was paid to minimizing the total signal distance through the combiner electrical paths and the symmetry of the circuitry to ensure phase equalization. An electronic-design-automation (EDA) package was needed to simulate the design and to effectively transfer data between the microwave software and the mechanical software. The goal was to create a structure, although complicated, that fit together the first time with no discrepancies.

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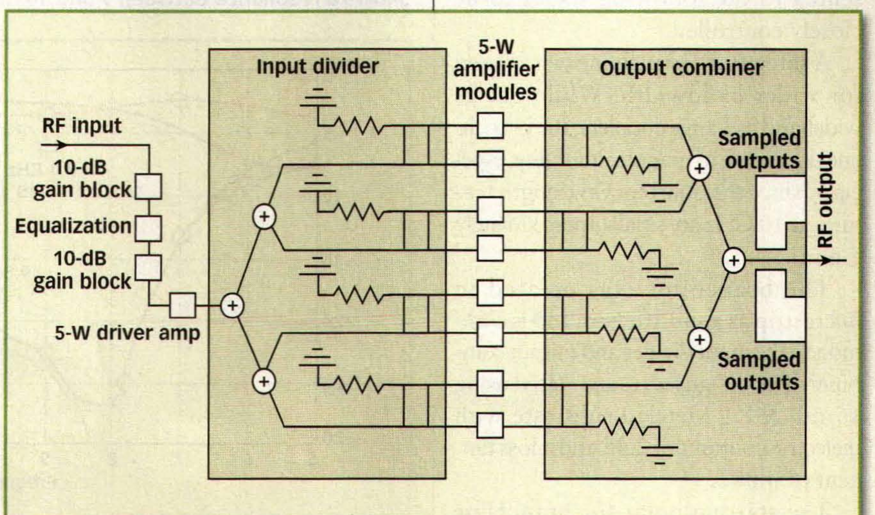
The EDA software chosen for the combiner design was Microwave Office (MWO) from Applied Wave Research (El Segundo, CA). The design flow began with schematic entry, then proceeded through linear simulation, layout, and electromagnetic (EM) simulation. The design was then tuned and optimized and the final layout was exported to a mechanical computer-



1. Eight 5-W MMIC amplifiers fit between the input divider and output combiner in the redesigned RF power amplifier.

aided-design (CAD) system. Feedback from the CAD system was used to tweak the final layout and Gerber data were produced from MWO.

The amplifier is specified to produce 30-W saturated power over the frequency range of 9.2 to 10.5 GHz. The redesigned version uses 5-W MMIC amplifiers, eight of which are used in the design **(Fig. 1)**. At the amplifier output, the forward and reflected power can be monitored. The combiner is implemented in microstrip on softboard. The output of each pair of MMIC amplifiers is combined with branchline couplers, and each pair of branchlines is summed using resistor-less Wilkinson combiners. The final combining stage is also a Wilkinson combiner. Thus, the eight MMIC amplifier modules are arranged as four balanced amplifiers with all of the well-known benefits that this type of topology provides.

Branchline Couplers

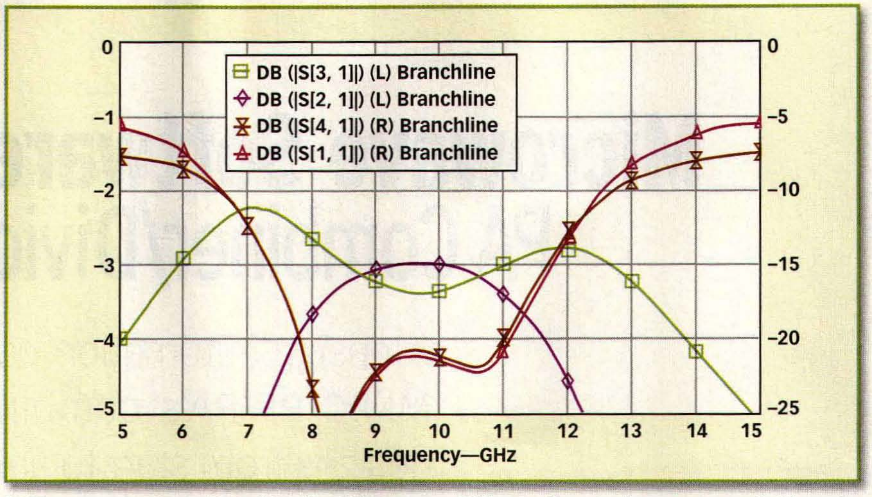
The branchlines were chosen as the first stage because:

- A branchline is a quadrature structure, required for the balanced design.
- They offer ease of manufacturing on a simple printed circuit.
- The load resistors are physically isolated from the main signal path.
- They provide a good match and isolation, allowing the impedances presented to the following stages to be closely controlled.

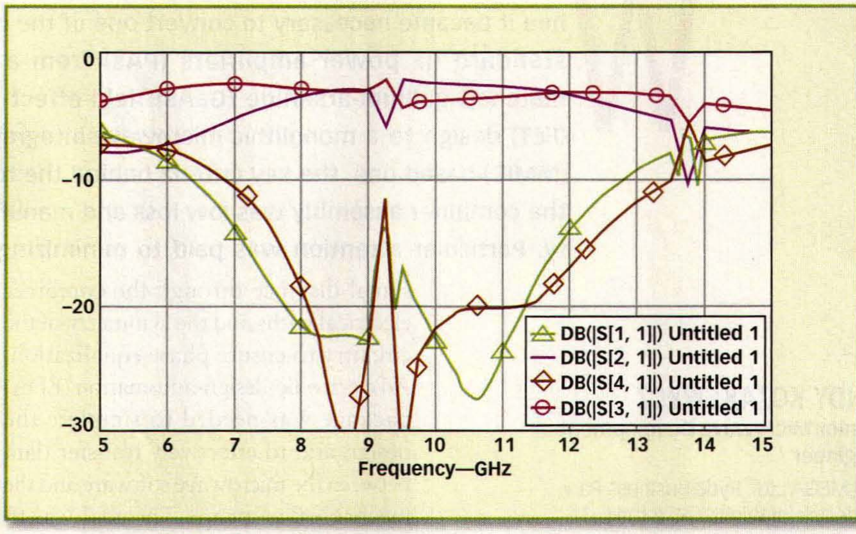
A three-stage branchline was chosen for wider bandwidth. While not as wideband as Lange couplers, the branchline offers ease of manufacturability, especially since the quarter-wavelength features at 10 GHz are small (approximately 5 mm).

The branchline was created in microstrip as a substructure and is common to the input divider and output combiner. The designs were simulated using 15-mil MX1 Metclad substrate with dielectric constant of 2.45 and a loss tangent of 0.002.

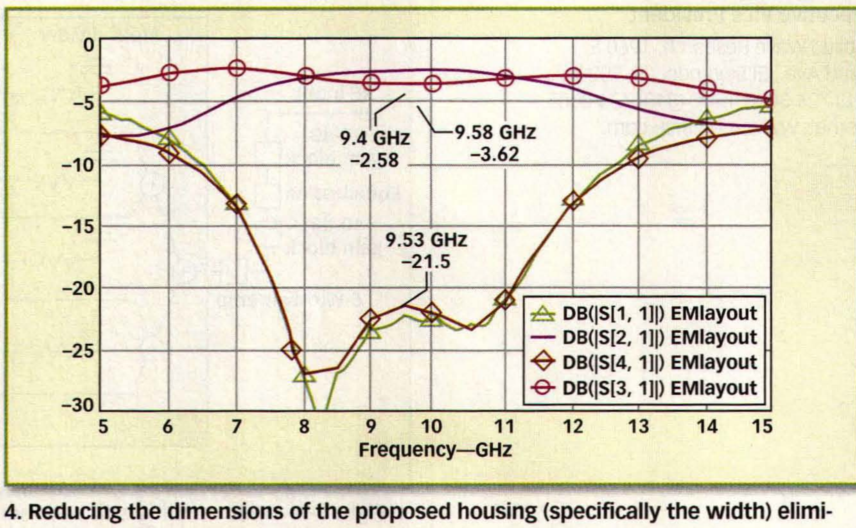
The starting point for branchline designs is usually from standard lookup tables for percentage bandwidth, which



2. These curves produced by the Microwave Office software, known as a yield analysis for branchline couplers, indicate that material and manufacturing tolerances do not adversely affect the design's behavior.



3. The response of the branchline coupler when enclosed in the proposed housing shows a resonance between 9 and 10 GHz.

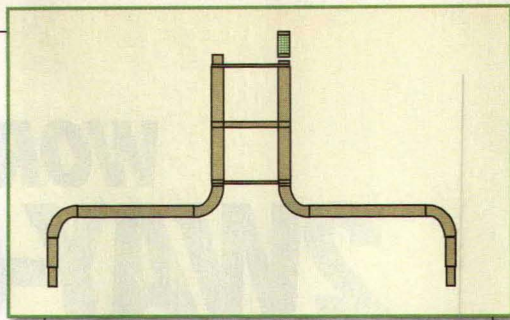


4. Reducing the dimensions of the proposed housing (specifically the width) eliminates the resonance shown in Fig. 3.

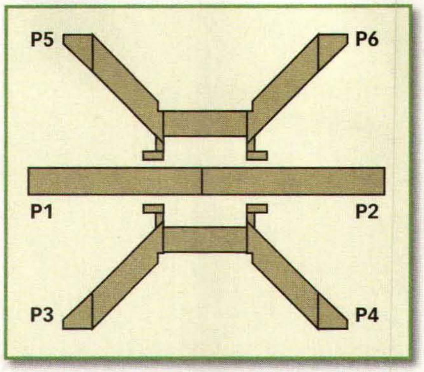
yields the impedances for each arm. A three-stage structure should have at least 30-percent bandwidth. Thus, at 10 GHz, it should be possible to produce an 8-to-11-GHz design.

The data were entered into a basic schematic with the line widths defined as variables. This allowed the circuit to be tuned.

MWO's linear simulator and automatic optimizer were applied to tune the line widths for less than 20-dB return loss over the required frequency range.



5. Data from an S-parameter software package and a physical layout cell were imported into Microwave Office to produce this branchline coupler layout.



6. The output sampling coupler of the PA shown here was modeled using Microwave Office's EM simulator.

Yield analysis was then applied, taking into account the substrate-material tolerances. In this case, the values used were:

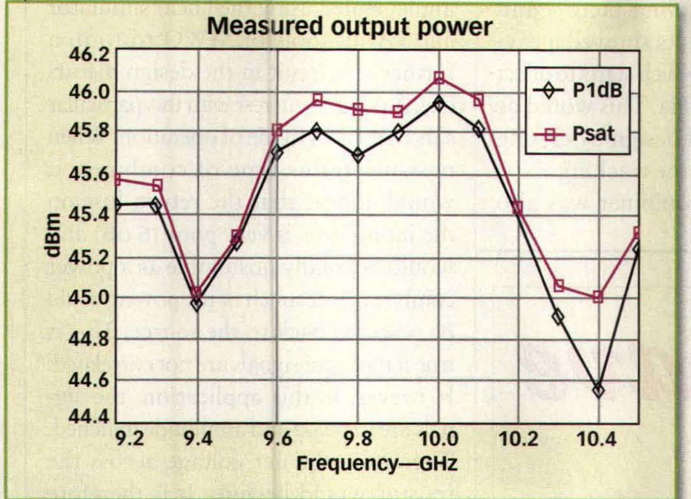
- Dielectric Constant of 2.45 ±0.04 (1.6 percent).
- Substrate thickness of 15 mm ±1 mm (38.0 × 2.5 cm) [7 percent].
- Line-width etching of ±8 percent.

The yield analysis shows that material and manufacturing tolerances do not adversely affect the design behavior **(Fig. 2)**.

Using MWO's automatic-layout tool, the coupler circuit was generated and made available for use as a subcircuit that could be imported to the EM simulator.

To complete the analysis of the branchline, the enclosure had to be taken into account. The microstrip design was to be enclosed in a solid aluminum (Al) sandwich into which the shapes of tracks and features could be milled out. The enclosure voids would need to be assessed to avoid any cavity resonance effects.

The branchline structure was exported to the MWO EM layout tool and was



7. These output-power curves illustrate the response of the complete RF PA assembly, including external gain blocks, drivers, and cabling.

simulated using the EM sight simulator. **Figure 3** shows the effect for a box footprint of 20 × 25 × 3 mm. The in-band resonance caused by the housing is clearly shown between 9 and 10 GHz. To eliminate this effect, the box width was reduced and **Fig. 4** shows the effect with the resonance tuned out.

To create a complete coupler subcircuit, 50-Ω load resistors rated at 10 W were included. An individual resistor was measured on a vector-network-analyzer (VNA) and scattering (S)-parameter data were extracted using S-parameter extraction software known as SPview. These data were then imported into MWO and a physical layout cell attached. To complete the branchline layout, the physical surface-mount-architecture (SMA) connections were taken into account. Due to external physical constraints these needed to be set on 40-mm centers. Using the completed data, the final branchline layout cell was produced **(Fig. 5)**.

Output Coupler

The output coupler provides sampled outputs. It is a standard edge-coupled line design with nominal 30-dB coupling factor. Four outputs are required: one pair to be used for front-panel forward- and reverse-power indicators, while the other pair is provided as direct front-panel RF connections for user monitoring.

The same design process as the branchline coupler was used. One problem that came to light during the design was the poor directivity that a microstrip implementation of an edge coupler provides. This is often solved in microstrip couplers by the inclusion of lumped capacitors fitted between the coupled lines at both ends. The linear simulation showed that suitable capacitors added in the schematic did improve directivity, but for a 10-GHz coupler the values required would be in the range of 0.01 pF, an impractical lumped value. It

was decided that the capacitors would be implemented as printed elements and this would best be modeled using the EM simulator. **Figure 6** illustrates the EM structure of the output sampling coupler.

The structure was trimmed manually for directivity, coupling factor, and return loss. The results showed a cavity mode at 14 GHz, which starts to affect the response at 11 GHz. This would be removed in the final design by closing the walls in around the tracking.

The Wilkinson combiner was also implemented using the linear simulator and layout tools of MWO to form a further subcircuit in the design hierarchy. A point of interest with this particular subcircuit is its mode of operation. When measuring this type of combiner, it would appear that the return loss on the input arms is very poor (6 dB) and would be totally unsuitable as a power combiner since much of the power would be reflected back to the source. This is true if the input signals are not correlated. However, in this application, the signals are in phase and amplitude matched. Therefore, the net voltage across the resistor would be zero. It is therefore possible to remove the resistor without affecting performance.

The redesigned version uses 5-W MMIC amplifiers, eight of which are used in the design. The eight MMIC amplifier modules are arranged as four balanced amplifiers with all of the well-known benefits that this type of topology provides.

The result of being able to remove the resistors is to allow the arms of the combiner to be "unwound" and used in the signal routing, thus reducing the overall signal distance and loss.

Completing The Module

The next step in the design process is to bring together the four branchline, three non-isolated Wilkinson and output couplers to form the complete module. The subcircuits were linked with a top-level schematic in MWO.

The whole package needed to be as small as possible to reduce losses. The minimum distance between the amplifier modules determines the spacing between input connections.

The layout of the microstrip printed-circuit boards (PCBs) was created in

MWO. The board outline was added and SMA connector positions were set before arranging the 50-Ω connecting tracks. When circuit positioning was fixed, the ground plane, via-, and screwholes were added as arbitrary copper (Cu) and drill holes.

The top-level input divider schematic was also created at this point using the same subcircuit data as the output combiner. A slightly different version of the branchline coupler had to be produced to maintain the ±90-deg. phase shift for the balanced amplifiers.

The data were then exported to three-dimensional (3D) CAD software SolidWorks as a 'DXF' file. Three-dimensional modeling in SolidWorks was used to generate the sculptured Al blocks. This highlighted small mechanical changes required by the design due to problems such as mounting hole clashes.

Gerber data were then exported from MWO for PCB manufacture and the metalwork was produced from the SolidWorks data.

To keep symmetry with the input divider circuitry, a stacked solution was decided upon with the input divider mounted above the output combiner and sandwiched between Al blocks.

The combiner/divider 3D modeling data were merged with similar data from other modules within the RF assembly to produce an overall 3D model of the complete RF assembly. The mechanical 3D modeling was followed to its logical conclusion with the integration into a chassis with a power-supply unit, fans, and airflow-baffle plates.

While not as wideband as large couplers, the branchline offers ease of manufacturability, especially since the quarter-wavelength features at 10 GHz are small (approximately 5 GHz).

The combiner/divider assemblies were tested back to back. A slight problem was indicated with a cavity resonance above the branchline load resistors. This was cured with the addition of a microwave absorber to the top lid. The back-to-back through loss was measured at 2.3 dB at 10 GHz. For the combiner alone, this equates to 1.15 dB. The simulation predicted 1.25 dB (including connector loss).

The complete amplifier RF assembly was tested with all external-gain blocks, drivers, and cabling installed with the satisfactory results shown in **Fig. 7.** MRF

(Continued from page 84)

The NMR probe using the shielded symmetrical-band resonator could be represented by the electrical circuit in Fig. 10. The block diagram of Fig. 10 is equivalent to a circuit with a scattering (S)-parameters matrix, coupling to the spectrometer as shown in **Fig. 11**.

The developed CAD allows one to evaluate the EM parameters of Z_c, L, C, R, G, and Q_n. The choice of the volume of the symmetrical band provides the corresponding resonator length d.

The shielded symmetrical band that is short-circuited at one of its extremities, has a behavior similar to a pure inductance L':

$$L' = L\,d \quad (H) \qquad (14)$$

Then the resonance is calculated, the value of the capacitor C' of accord, by using the following relation:

$$C' = \frac{1}{L'\omega_0^2} \quad (F) \qquad (15)$$

The resistance R' is chosen to consolidate the adaptation between the coaxial line and the resonant circuit at the resonant frequency.

With a numerical approach using the transmission-lines theory,[5] variation of the reflection coefficient S_{11} at the input of the probe can be shown **(Fig. 12)**. The simulation results of NMR probes at 500 MHz, 1 GHz, and 2 GHz are presented in the following points **(Figs. 12 and 13)**:

1. NMR Probe at 500 MHz.
   - Shielded symmetrical band: $r_o = 20$ mm, $r_b = 4r_o$, w = 4 mm, d = 20 mm, $\alpha = 1.48$ deg., $f_o = 500$ MHz, $\epsilon_r = 1$.
   - Inside volume of the ring: 50 cm^3, C' = 17 pF, and R' = 50 Ω.
2. NMR Probe at 1 GHz.
   - Shielded symmetrical band: $r_o = 20$ mm, $r_b = 4r_o$, w = 4 mm, d = 20 mm, $\alpha = 5.91$ deg., $f_o = 1$ GHz, $\epsilon_r = 1$.
   - Inside volume of the ring: 50 cm^3, C' = 5.24 pF, and R' = 50 Ω.
3. NMR Probe at 2 GHz.
   - Shielded symmetrical band: $r_o = 20$ mm, $r_b = 4r_o$, w = 4 mm, d = 20 mm, $\alpha = 23.64$ deg., $f_o = 2$ GHz, $\epsilon_r = 1$.
   - Inside volume of the ring: 50 cm^3.
   - C'= 0.705 pF and R' = 50 Ω.

The authors have proven that for some geometrical parameters, the probes using the shielded symmetrical-band resonator present a higher-quality coefficient than those using the shielded split-ring resonator. MRF

REFERENCES

1. N. Benahmed, "Numerical Simulation of the Shielded Symmetrical Band Resonator for NMR Application," Master's Thesis, University of Tlemcen, Algeria, 1997.
2. F. Tauelle, D. Massiot, J.C. Rifflet, J.P. Coutures, *Bulletin Magnetic Resonance 11*, pp. 314-316, 1990.
3. H.J. Schneider and P. Dullen Kopf, *Rev. Sci. Instrument*, Vol. 48, 1977.
4. W.N. Hardy and L.A. Whitehead, "Split Ring Resonator For Use in Magnetic Resonance From 200-2000 MHz," *Rev. Sci. Instrument*, Vol. 52, No. 2, February 1981.
5. N. Benahmed, M. Feham, and M. Kameche, "Finite Element Analysis Of Planar Couplers," *Applied Microwave & Wireless*, Vol. 12, No. 10, October 2000.

Multichannel IF Amplifier Bypasses AGC Circuitry

Replacing the AGC in a direct-conversion Rx with a multichannel IF amplifier offers designers a more economical approach.

Direct-conversion or zero-intermediate-frequency (IF) receiver (Rx) designs are very attractive, but they have drawbacks. One major drawback is the automatic-gain-control (AGC) requirement. This article investigates how to avoid AGC in certain zero-IF designs, particularly in a binary-phase-shift-keying (BPSK) data Rx, using a multichannel, limiting IF amplifier. At the end of the article, a practical 8-channel, limiting IF strip and corresponding Costas-loop BPSK demodulator are presented.

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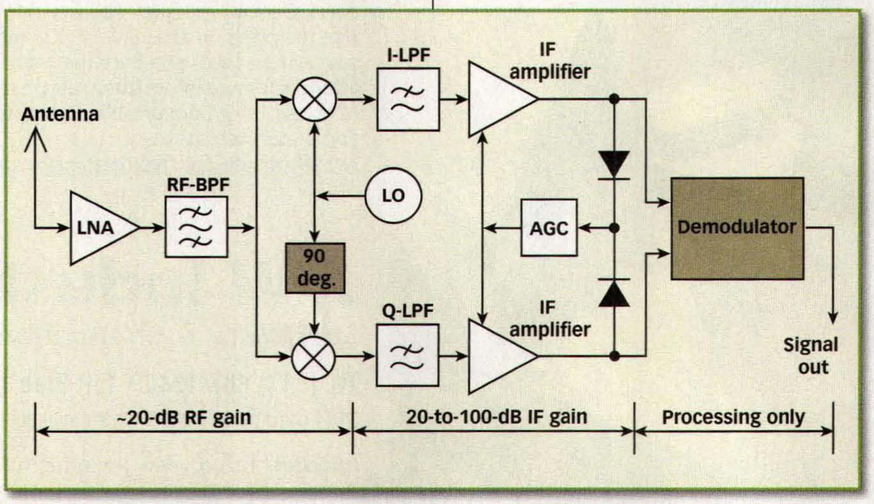
Direct-conversion or zero-IF Rxs are becoming increasingly popular due to the reduced requirements for expensive and/or tunable components that are in the RF front end. As shown in **Fig. 1**, a direct-conversion Rx requires only a small amount of RF gain (approximately 20 dB) to overcome the mixer noise. Even more important, since there is no image response, as in a superheterodyne Rx, RF bandpass filtering requires only low-quality factor (Q), inexpensive fixed-tuned resonators to eliminate very strong out-of-band signals.

Rx selectivity is defined by simple lowpass filters at the zero IF. Also, most of the required signal gain (20 to 100 dB) is obtained at the relatively low IF,



1. The gain distribution in a direct-conversion Rx shows that just a small amount of RF gain (approximately 20 dB) is needed to negate the mixer noise.

reducing cost and power consumption. Signal processing is slightly more complicated than in a superheterodyne Rx, but the additional processing is still more than compensated for by the reduced RF requirements.

Unfortunately, direct-conversion or zero-IF Rxs have a number of drawbacks that make their practical implementation difficult or even impossible. Most of these drawbacks are described in detail elsewhere:[1] effects of local-oscillator (LO) leakage, DC offset and/or AC coupling of the two in-phase (I) and quadrature (Q) IF amplifiers, and effects of various nonlinearities in the circuit.

One important consideration that is frequently overlooked by Rx designers is the AGC requirements. A direct-conversion or zero-IF Rx requires that the IF chain operate in linear, non-limiting conditions even while receiving constant-envelope signals, such as various forms of frequency-shift keying (FSK) and PSK. When a constant-envelope RF signal is downconverted to the I and Q IF channels, only the sum of the powers of the I and Q channels is constant. The instantaneous powers of the I or Q channel are variable at a rate comparable to the (unwanted) frequency offset of the Rx LO with respect to the transmitter (Tx).

Simple limiting of the I and Q channels introduces a large amount of distortion, degrades the signal-to-noise ratio (SNR) and usually makes the demodulation impossible even for simple modulation formats such as symmetrical BPSK. To keep the I and Q IF amplifiers within their linear regions of operation, some form of AGC is required in a practical Rx.

IF Amplifiers

The I and Q IF amplifiers in a direct-conversion Rx are AC coupled in order to avoid various offsets. However, their lower corner frequency is very low. Usually, the AGC time constant has to be faster than the lowest frequency that is supported by the I and Q IF amplifiers. Designing a fast AGC for slow amplifiers is more demanding than an AGC circuit for a narrowband RF amplifier. Last, but not least, both I and Q IF channels require a common AGC that acts simultaneously on both channels.

The AGC itself adds unnecessary constraints to the performance of the Rx, particularly when receiving short bursts of digital data. Even when the attack and decay time constants of the AGC are chosen carefully, the data transmission still requires additional guard times at the beginning of each transmission burst.

The main design idea of a direct-conversion Rx is to trade critical and expensive RF components, like high-Q, tunable filters required in a classical superheterodyne Rx, for increased circuit complexity such as two mixers and two I and Q IF amplifiers in a zero-IF design. In this article, this idea is extended even further—a critical AGC circuit is replaced by a more complex multichannel IF design that uses only simple, inexpensive, and reliable limiting amplifiers.

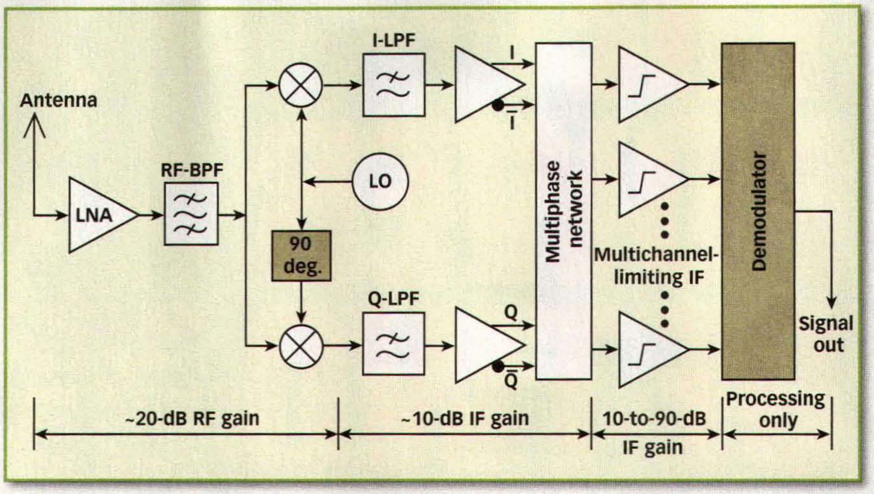
When a BPSK or quadrature-PSK (QPSK) RF signal is downconverted to the I and Q IF channels, the instantaneous powers of the latter fluctuate with the frequency offset of the Rx LO.

The main function of the BPSK (or QPSK) demodulator is to track the LO frequency and phase offset and produce a linear combination(s) of the I and Q signals to restore the original modulating signal(s).

In other words, at any particular instant in time, there exists a linear combination of the I and Q channels that will restore the original, constant-envelope signal. The multichannel IF design idea is straightforward—build an IF strip with as many channels as possible, each of them fed with a different linear combination of the I and Q IF signal. The function of the demodulator is to simply select the correct channel out of the many available.

Since the good channel carries a constant-envelope signal in the case of BPSK, QPSK, or some other simple constant-envelope modulation formats, all IF amplifiers can be simple limiting amplifiers without AGC. The previously mentioned design idea is represented in **Fig. 2**. The I and Q IF signals feed a multiphase (resistor) network producing many different linear combinations of the two original IF channels. Most of the gain in the receiving chain is provided by the following limiting amplifiers. Finally, the demodulator simply switches among the limiter outputs to track the good signal.

Theoretically speaking, the number of limiting IF channels should be as large as possible to avoid signal dis-



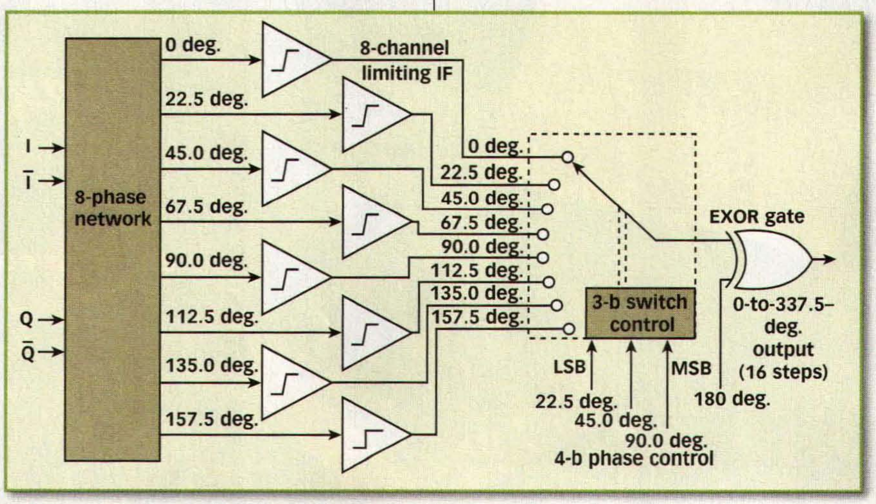
2. This direct-conversion Rx with a multichannel, limiting IF amplifier is an example of a design that does not use AGC.

tortion. But how many limiting IF channels are required in practice? A phase error consisting of 22.5 deg. decreases the SNR in a BPSK demodulator by approximately 0.7 dB. Therefore, a 16-channel limiting IF amplifier should be sufficient in a zero-IF BPSK Rx that has a 16-phase demodulator and no AGC.

The multichannel, limiting IF amplifier can be further simplified by considering that phase reversals or 180-deg. phase changes can also be performed on the output of a limiting amplifier using an analog multiplier or an EXOR gate. Therefore, a 16-phase demodulator requires only an 8-channel, limiting IF as shown in **Fig. 3**. The single limiting channels are fed with signal phases of 0, 22.5, 45.0, 67.5, 90.0, 112.5, 135.0, and 157.5 deg., while an additional 180-deg. phase shift can be added by an EXOR gate when required. Phase selection requires four control bits. The most-significant bits (MSB) [180-deg. steps] controls the EXOR gate while the three least-significant bits (LSBs) [22.5-, 45.0-, and 90.0-deg. steps] select one of the eight limiting IF amplifiers. Using all four control bits, the phase of the output signal can be selected in 16 steps from 0 to 337.5 deg.

A Practical Demodulator

Multichannel, limiting IF strip, and corresponding Costas-loop BPSK demodulators for 1.2288 Mb/s were built and



3. Only an 8-channel limiting IF is required for a 16-phase demodulator that selects the phase of the output signal.

tested. In particular, the IF strip and demodulator were designed as a plug-in replacement for an earlier BPSK demodulator,[2] so that immediate comparisons were possible. For the latter demodulator, a BPSK signal source with a calibrated carrier-to-noise output was available from previous experiments.

The circuit diagram of the 8-channel, limiting IF amplifier is shown in **Fig. 4.** LM311 voltage comparators are used as limiting amplifiers. The availability of differential inputs on the LM311 comparators simplify the design of the multiphase network. The latter only requires eight resistors in the ratio 1:$\sqrt{2}$ (2.7 kΩ and 3.9 kΩ in Fig. 4). The 8 × 100-kΩ resistor ladder provides only input biasing, while the four inputs I, /I, Q, and /Q are capacitively coupled. Of course, the LM311 outputs require 1 kΩ pull-up resistors to drive standard TTL or complementary-metal-oxide-semiconductor (CMOS) logic.

A corresponding Costas-loop BPSK/ demodulator's principle of operation is similar to that of the earlier demodulator[2] and is based on rotating switches to counter rotate the signal phasor. Since the input signals are already limited and amplified to logic levels, two digital selectors (74HC151) are used as rotating switches. The switches are driven by a bidirectional counter using two 74HC191 devices operating as a digital voltage-controlled-oscillator (VCO). EXOR gates are used for the MSB and for the I × Q multiplication that is required in a Costas-loop demodulator. Finally, D-flip-flops (74HC174) are used to remove any switching transients or metastable states. The 8-channel limiting IF strip and Costas-loop BPSK demodulator were built on a double-sided printed-circuit board (PCB). Practical tests have shown that the new IF chain and demodulator achieves the same bit-error-rate (BER) performance as the old demodulator with analog rotating switches presented in the earlier demodulator.[2]

New Versus Old

The main difference between the new and old demodulator is in the acceptable dynamic range of the input signals. While the old demodulator requires large input signals between 1 and 3 V_{pp} (approximately 10-dB dynamic range) for correct operation, the new demodulator with its limiting IF strip operates without BER degradation for input signals ranging from 30 mV_{pp} to 3 V_{pp} (approximately 40-dB dynamic range).

The lower limit of approximately 30 mV_{pp} is set by the input offset volt-

(Continued on page 145)

Conquering the broadband filtering problem

ELECTRONIC EQUIPMENT that operates at or beyond the gigaHertz range is not limited to communications anymore. Computers are there, and some automotive electronics are coming. A problem for designers attempting to meet tougher EMC specifications is optimizing a passive-component broadband filter for operation at 1 GHz and above. It currently takes a combination of filter types, each covering a different band of frequencies up to 1 GHz. A new technology to reduce the component count and yield more effective broadband filtering is explained in a paper, "A Broadband Filter Proves Itself In Multiple Dielectrics," which appears in *ITEM Update 2001*.

Engineers at two companies—X2Y Attenuators, LLC (Erie, PA) and Amphenol Aerospace Corp. (Sidney, NY)—have devised a single-package passive-component filter that replaces three capacitors that are normally required to handle the two noise sources in a circuit: common-mode noise and differential-mode noise. A common filtering practice uses two "Y"-connected capacitors to shunt common-mode noise to ground and one "X" capacitor to shunt differential-mode noise from one line to another. Even if the three capacitors are carefully matched and located in the circuit, they will not attenuate equally and can create an imbalance that itself is a source of noise. Thus, the reasoning behind the X2Y technology is the combination of one "X" and two"Y" capacitors in a single package to eliminate the imbalance effects noted before, as well as other undesirable consequences resulting from the use of individual components. The capacitors are housed so that the new component is effectively a four-terminal capacitor.

The configuration, however, is only part of the new filter technology. The first models were ceramic capacitors and proved to be well-suited for filtering dual-mode noise in +12-VDC motors. For high-speed data lines, ferrites were used in the X2Y structure because the inductive nature of ferrite material supports low signal distortion. This is a unique use of ferrites as the basis for capacitors in high-frequency applications, but testing indicates that ferrite material is suitable to provide low capacitance, satisfactory insertion loss, and minimal signal distortion.

Other materials are also being investigated as dielectric candidates for the X2Y structure, such as film dielectrics and MOV. For more information, contact:

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Low-noise design basics appear in Part 2

BACK IN AUGUST 2001, this column reported on a brochure, "The 10 Basic Steps to Successful EMC Design." However, only the first five steps were described. Steps six through 10 are the subject of a second brochure bearing the same title. These steps offer information on filtering, filter installation, sealing an enclosure, dealing with analog circuits, and switch-mode power supplies.

The basic rule of filtering, according to the brochure, is "do not allow a conductor to exit or enter a system without doing something to it; either shield it or filter it." When installing the filter, the ground leads must be connected to the enclosure with short leads. A filter with long leads is similar to not having a filter at all.

A suitable enclosure would be a box without openings. In the real world, however, all boxes must have openings for switches, buttons, lights, etc. At high frequencies, the openings tend to interrupt current flow. When the length of an opening approaches a half wavelength, the opening (aperture) resonates and energy propagates through the slot. A design goal should be that no opening exceed 1/10 of a wavelength of the highest frequency of interest. At 1 GHz, for example, this works out to be 3 cm (slightly more than an inch). Even a hairline crack, the brochure states, will leak very nicely.

Analog circuits are a problem since their many positive-negative junction components, which can rectify and demodulate out-of-band signals, then becoming in-band signals to the circuits of the system in the process. Lowpass filtering on input lines can help reduce the noise effects.The primary noise culprit in switch-mode power supplies is the FET switch, which can generate voltage transitions up to +700 VDC with transition time in the gigaHertz range. Snubber circuits across a ringing circuit can increase the damping, thus making the circuit more stable. Both notes can be obtained from the company.

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cover story

System Simulator Melds DSP And RF Analysis

This robust system simulator provides the many models and engines needed to perform analog and digital analysis on modern communications systems.

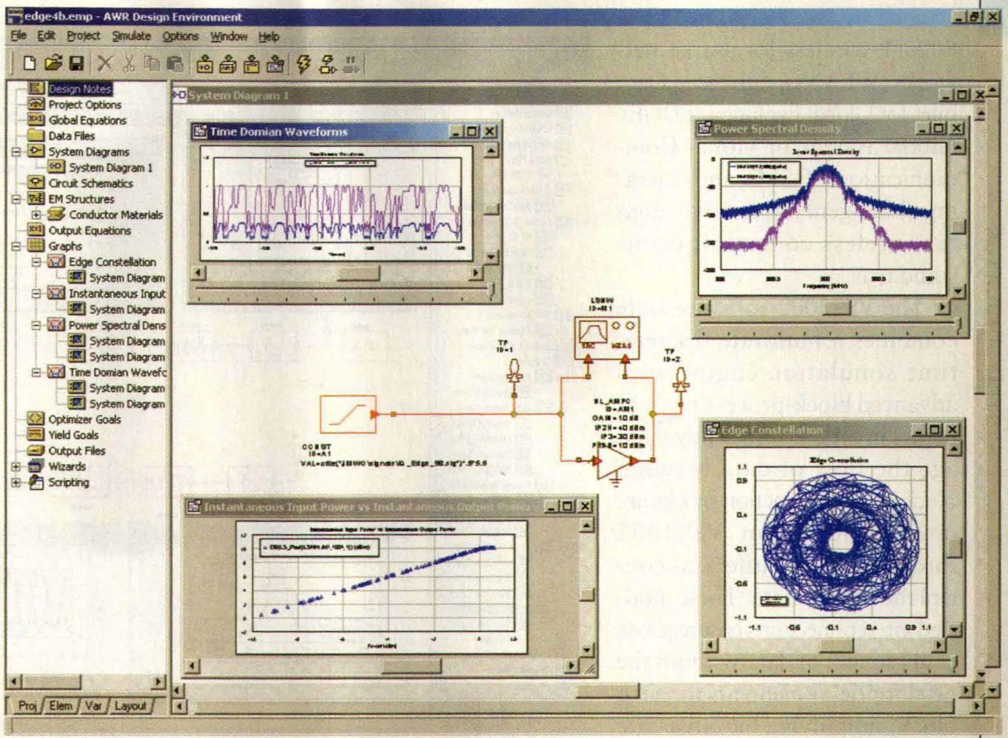
JACK BROWNE
Publisher/Editor

Circuit simulators provide a preview of a component's electrical performance. But system simulators can provide "the big picture," modeling the interactions of complex signals and multiple components. And that picture may have gotten a lot clearer, with the introduction of the Visual System Simulator 2002 (VSS2002) electronic-design-automation (EDA) tool from Applied Wave Research (El Segundo, CA). The new software allows designers to analyze systems from a receive or transmit antenna all the way through the RF and digital-signal-processing (DSP) sections of a receiver (Rx) or transmitter (Tx). The software suite is well-suited for simulating the performance of wireless communications systems, high-speed wire-line communications systems, and optical-communications systems.

VSS2002 enables users to quickly construct block diagrams of complex systems, then analyze the performance of selected sections or an entire system using built-in measurement functions and sophisticated signal generators. The signal-generation simulation tools can model virtually any form of modulation scheme, including amplitude modulation (AM), frequency modulation (FM), orthogonal-frequency-division-multiplex (OFDM) modulation, quadrature amplitude modulation (QAM), minimum-shift-keying (MSK) modulation, and phase-shift-keying (PSK) modulation.

VSS2002 represents a major advance in the Advanced Communication Links Analysis and Design Environment (ACOLADE) simulation technology acquired by Applied Wave Research

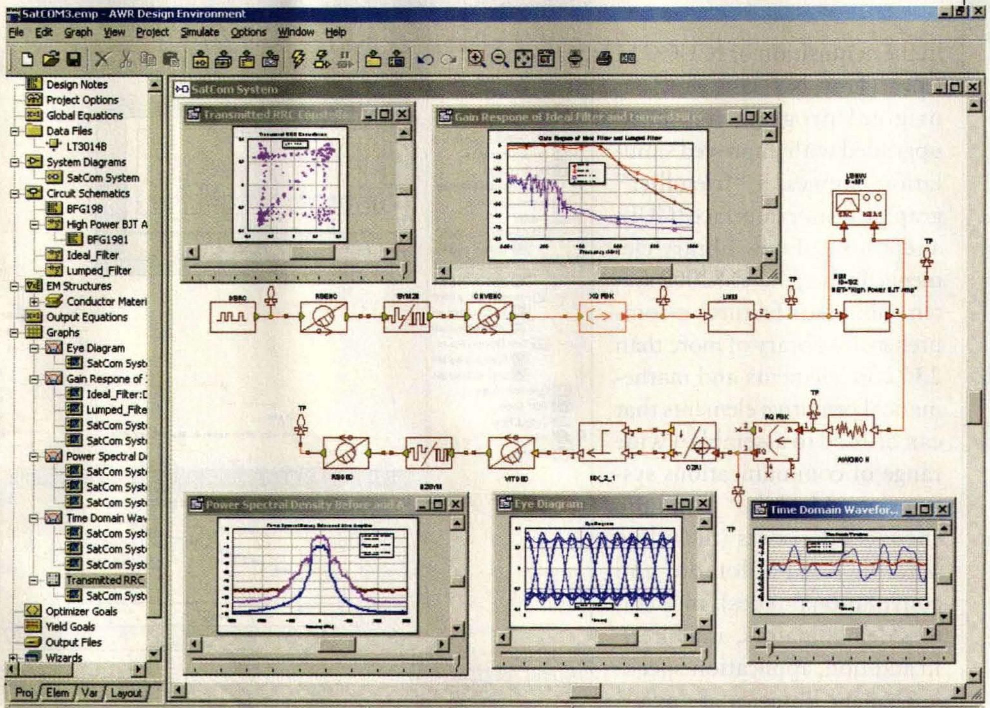
in the acquisition of ICUCOM Corp. (Troy, NY) last year. That original program has been upgraded with improved simulation engines, a "friendlier" graphical-user interface (GUI), and a host of new library elements. In fact, the VSS2002 system simulator features a comprehensive library of more than 230 core elements and mathematical primitive elements that can be used to assemble a wide range of communications systems. Models include encoders/decoders (including Viterbi, Reed-Solomon, and convolutional types), modulators/demodulators, and filters. In addition, application-specific element libraries are available for numerous standards, including IS-95 cellular, IEEE



1. The VSS2002 system simulation software was used to model the effects of an EDGE signal on the performance of a power amplifier (PA).

802.11 wireless local-area networks (WLANs), Enhanced Data rates for Global Evolution (EDGE), Global System for Mobile Communications (GSM), and emerging third-generation (3G) digital wireless communications standards.

The VSS2002 software suite combines a multirate discrete-time simulation engine with advanced block-processing techniques in order to efficiently manage the flow of data between blocks. System function blocks are interconnected in VSS2002 through elastic buffers to control the flow of data. These modeled interconnections ensure proper alignment of data without the need for delay elements for each block, simplifying bit-error-rate (BER) simulations. These interconnects support synchronous and asynchronous data transfers, and allow operators to understand the effects of signal impairments, such as noise and distortion, on system performance. Impairments can be modeled in either the frequency domain or time domain.



2. The VSS2002 software suite can effective model the end-to-end performance of a satellite-communications system by tracking a signal from a Tx's encoder to the Rx.

The system-level software can simulate a wide range of performance figures of merit, including power spectral density, error-vector magnitude (EVM), and adjacent-channel power ratio (ACPR). A real-time tuning mode allows operators to change any number of component performance parameters, such as receive low-noise-amplifier (LNA) gain and noise figure, and instantly see the effects on system-level performance. In addition, function blocks can be programmed to run on a sample-per-sample basis for handling feedback loops.

VSS2002 has been designed to work with the company's Microwave Office 2002 circuit-design software suite. System designers can develop specifications in VSS2002 that can then be passed to Microwave Office 2002 for development of RF and microwave components, or vice-versa. Together, the two programs represent a modeling environment that can perform component- and system-level simulations simultaneously. For example, the two software suites can be used to adjust the bias on an amplifier or transistor while analyzing the system BER. Furthermore, VSS2002's versatile application-programming interface (API) provides seamless integration to other modeling tools, including Matlab.

How well does the VSS2002 software suite solve communications-system modeling problems? A pair of examples may help to demonstrate the new software's effectiveness. In one case, VSS2002 was used to evaluate the performance of an amplifier design in handling a complex EDGE signal. The vector-modulated EDGE signal feeds the amplifier model while an operator can set gain, output power at 1-dB compression, midband output second-order intercept point (IP2), midband output third-order intercept point (IP3), and group delay. In this example **(Fig. 1)**, the amplifier gain was set to 10 dB, and the EDGE signal constellation at the amplifier's output (lower righthand side of Fig. 1) does not reveal any zero crossings. By using the Large Signal Network Analyzer (LSNW) block in VSS2002, the instantaneous input power to the amplifier can be plotted as a function of the amplifier's instantaneous output power. Using this transfer curve, the power swing of the EDGE signal is approximately 10 dB and the amplifier starts to go into saturation at about 10 dB, which is the setting of the output 1-dB compression point. After 3 s, the power spectral-density plot, an averaged 4096-point Fast Fourier transform (FFT) reveals spectral regrowth to the amplifier.

In the other example, a full end-to-end system is simulated. This simulation starts with a digital source that is encoded using Reed-Solomon (RS) and convolutional encoding, typically of the encoding scheme used in satellite communications (and known as concatenated encoding). Users have a choice of parameter setting for both encoders. The encoded data are then passed to a quadrature-PSK (QPSK) Tx, also with a choice of parameter settings. Among the Tx filters are root-raised-cosine (RRC), raised-cosine (RC), half-sine, Gaussian, and Gaussian-MSK

(GMSK) types, or no filtering at all. A user can then define the center frequency and power level of the transmitted signal.

In this example, an RRC filter with $\alpha = 0.35$ was chosen. The output of the QPSK Tx is then sent to a lowpass filter, using the S_{21} parameters for a filter designed in Microwave Office 2002. A wide variety of suitable filters is available in VSS2002, or S_{21} filter data can be imported from Microwave Office 2002 or other programs to simulate a "real-world" filter. The output of the filter is then send to an amplifier block based on imported AM/AM and AM/phase-modulated (PM) traveling-wave-tube (TWT) characteristics. The program also allows users to work with suitable TWT models that are not dependent on external data. An additive-white Gaussian noise (AWGN) channel was then selected from among the many channel models in VSS2002 to simulate the front-end noise of a Rx. The output of the AWGN block was then passed to a coherent QPSK Rx that can automatically set its parameters to correspond with the settings of the Tx. The data were then decoded using a soft-decision Viterbi decoder followed by an RS decoder.

As the simulation is running, data can be monitored in various formats. In this case, the spectral regrowth of the signal due to the TWT, as well as the time-domain waveforms at various points in the system were selected **(Fig. 2)**. VSS2002 automatically aligns the received and transmitted data, providing the engineer with the flexibility to change filter parameters and/or encoding schemes without having to manually account for the inherent group delay. A user can also monitor constellation and eye diagrams in real time. For additional analysis, a gain plot of the filter response was overlaid with the power spectral density of the transmitted signal.

The VSS2002 software, which is available as a no-cost upgrade for current ACOLADE customers under support, is available for computers running the Windows 98, 2000, ME, NT, and XP operating systems. A free evaluation copy of the software can be downloaded from the company's website at www.appwave.com/products/vss2002. html for a 30-day trial period. P&A: $15,000 to $33,000, depending upon capabilities; second quarter 2002. **Applied Wave Research, Inc., 1960 East Grand Ave., Suite 500, El Segundo, CA 90245; (310) 726-3000, FAX: (310) 726-3005, e-mail: info@mwoffice.com, Internet: www.appwave.com.**

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Software Suite Simplifies Simulations

This Windows-based EM simulator offers the capability of breaking designs into smaller blocks or subcircuits to speed simulations without sacrificing accuracy.

DR. MARTIN TIMM
Application Engineer
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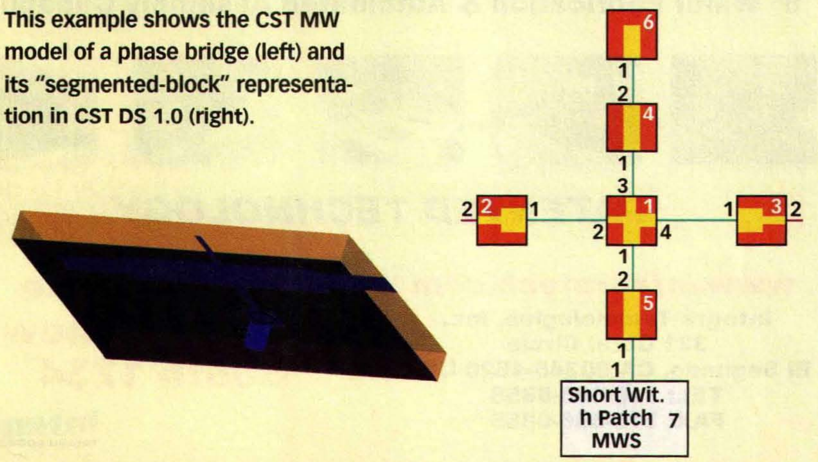
Speed in simulation is usually at the cost of accuracy. Fortunately, however, the newest version (Version 1.0) of the CST Design Studio™ (CST DS) software suite from CST of America, Inc. (Wellesley, MA) provides three-dimensional (3D) electromagnetic (EM)-field simulation of complex structures and systems without the long processing times associated with EM simulators. The Windows-based com-puter-aided-engineering (CAE) tool recombines the smaller components of complex systems, each described by its scattering (S)-matrix, supporting rapid analysis with reduced computer-memory requirements.

The latest version of CST DS is designed to be a universal platform to manage the numerical simulation and the design of complex structures. It offers an extensive application range, from microstrip circuits and systems to waveguide. It can consider higher-order mode coupling between components so that there is no loss in accuracy when analyzing a complex system in terms of its components. Growing complexity of high-frequency circuits and systems makes this capability of analyzing complex structures by their component parts extremely attractive.

Most complex systems can be split into parts that are described by either analytic models, common parts that are simulated repeatedly (if there is no analytic description available), and, parts requiring full 3D analysis. Still, partitioning must be performed at suitable positions in a system. Any analysis must also consider how the EM fields in one section will affect other components.

Therefore, for accurate analysis, consideration must be given not only to the fundamental mode at boundaries between parts, but also to all higher-order modes. The approach of breaking down complex structures into accessible parts may naturally be inverted to perform simulations on complex systems by using already-available simulation results of components and subsystems. Ideal-

This example shows the CST MW model of a phase bridge (left) and its "segmented-block" representation in CST DS 1.0 (right).



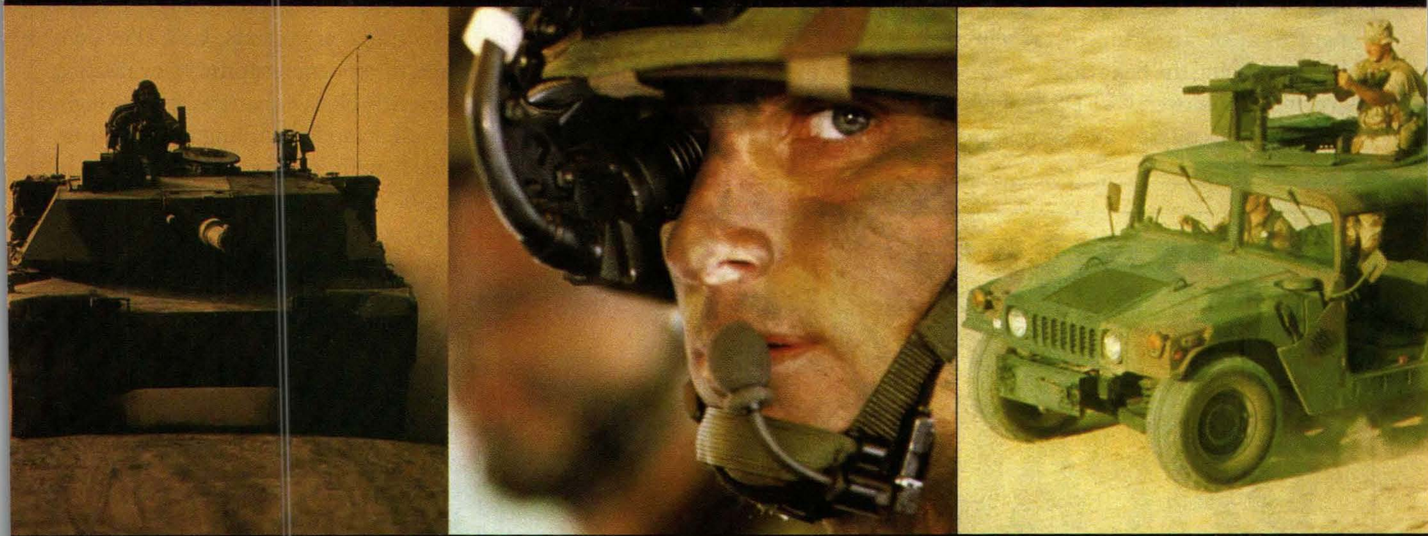
ly, this simulation approach should provide the capability of modifying single components without having to recalculate an entire system.

CST DS can compute the system response of a complex structure using a combination of the S-matrices of its constituent components (the "blocks" of a block diagram). Single S-matrices might stem from several sources, including measurements or manufacturers' component data sheets.

Analytic solutions for the EM fields and the S-parameters on several kinds of transmission line are well-known and there is no need to include them in any kind of numerical simulation. Analytical models for many EM devices, such as perfect absorbers, phase shifters, and devices with well-defined reflections are already implemented in CST DS (and the collection is constantly being increased and upgraded). They can be included, changed, and optimized with literally no computational cost. Models include waveguides, striplines, junctions, and other structures. All of these blocks are parameterized and can be easily changed or adapted according to an application.

The next source of block descriptions is the built-in element library. Its elements are represented by a 3D, parameterized CST Microwave Studio (CST MWS) file. The (generalized) S-matrices are derived by a 3D field simulation. CST DS keeps track of previously performed simulations and caches the results for particular parameter sets. At the moment, the library has a number of waveguide elements, such as dividers, irises, and a set of microstrip structures including junctions, bends, and couplings. A user may select a library element if the analytic description appears not to be sufficient or is simply not available. For example, for a T-junction, parameters accessible to the user are the width of the three striplines, the conductivity of the metal, along with the height and permittivity of the substrate. After setting these parameters, CST DS checks if this simulation has already been performed. If the answer is yes, CST DS will use these previous results. If the answer is no, CST MWS will be started and run to create the required solution. The S-parameters are embedded so that the extent of the T-junction is zero and is only taken into account as an effect. In orderto create an extended microstrip structure, striplines (e.g., from analytic models) could be attached to the three ports. The CST DS library is user-extendable. Elements can be added through CST MWS files and parameterization of these files is accessible through the CST DS graphical-user interface (GUI). Connection to other EM solvers is in development.

TAKING MILITARY COMMUNICATIONS TO A HIGHER LEVEL.



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External solutions for EM problems can also be included. The Touchstone interface supports the use of measurement data or any kind of tabulated data describing the behavior of an EM structure. Moreover, CST DS integrates tightly to 3D microwave simulators, such as CST MWS and the 3D Planar EM software tool from Sonnet Software (Liverpool, NY), where parts that are not analytic blocks or library elements can be simulated. In particular, the generalized S-parameters for an arbitrary number of ports and modes derived by CST MWS add immense value in accuracy and versatility.

Having defined the complete set of structure components, CST DS calculates the system response by evaluating the single block S-matrices, taking higher-order mode coupling into account. One benefit is that the modification of one block leaves other blocks untouched.

The results can be visualized as impedances or S-parameters using several views, including amplitude/phase, real/imaginary part, polar or Smith Chart plots. Text boxes and images can be included for documentation purposes. The Windows-based CST DS software offers a Visual Basic for Applications (VBA)-compatible interface, including editor and macro debugger; the software is seamlessly integrated into an object-linking and embedding (OLE) automation environment, allowing CST DS to steer or be steered by other programs using this mechanism.

CST DS software provides the same accuracy of a full 3D EM simulator in a fraction of the time. In fact, parts of a system that can be described analytically do not have to be included in numerical field computation, allowing the computational volume to be reduced.

A simple example helps to demonstrate the power of the CST DS software: a phase bridge used in the CST Microwave Studio software **(see figure)**. The phase bridge's elements were selected from the set of analytic blocks: microstrip steps (numbers 2 and 3 in the figure), striplines (4,5) and open stripline (6), library elements (1), and an external CST MWS block (7). Once the library elements and the external blocks have been simulated, the structure can be modified in many ways by altering parameters of the blocks.

Since simulation time is reduced significantly compared to conventional tools, CST DS Studio enables fast full-parameterization and optimization studies for complex systems, while maintaining high accuracy. **CST of America, Inc., 8 Grove St., Suite 203, Wellesley, MA 02482; (781) 416-2782, FAX: (781) 416-4001, Internet: www.cst-america.com.** MRF

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JACK BROWNE
Publisher/Editor

Accelerated life testing can reveal a great deal about the reliability of a high-frequency component or assembly. Although this testing usually requires the creation of a sophisticated, custom measurement setup, there is now a better way. The Automated Accelerated Reliability Test System (AARTS) from Maxwell Technologies (San Diego, CA) is a turnkey system that incorporates all of the RF, DC, and thermal capability needed for reliability/parametric testing on RF and photonic devices and components.

The AARTS **(see figure)** combines specially designed hardware and software to simplify accelerated life testing on up to 32 RF and photonic units at one time. The DUT can even differ in design and function, since each DUT is independently biased and RF controlled and is mounted in an independently controlled fixture. Each DUT fixture can provide two independent bias voltages, RF input and output connections, and temperature control. When measurements are completed on a DUT, it can be removed from the system and replaced with another unit without interrupting measurements on the other installed DUTs.

This version of the AARTS is a triple-bay rack-mount system configured for 32 channels of testing.

Versions of the GPIB-controlled system are available for testing 4, 8, 16, or 32 RF devices at a time over ranges of 0.6 to 3.0 GHz, 0.9 to 10 GHz, and 2 to 18 GHz. Up to 96 bias channels are available for power connections. Major AARTS subsystems include the Heater Control Unit (HCU) which is designed to control the base-plate temperature of each DUT within ±2°C over a range of +40 to +250°C. Temperature in each DUT fixture is monitored through a dedicated thermocouple sensor.

The RF Distribution Unit (RFU) generates and routes RF signals to the DUTs and passes RF output signals from each DUT to a measurement subsystem. The RFU can provide up to +15-dBm RF input power per DUT (or more with amplification), and can handle as much as 30-W output power per DUT. The RFU features an input-power adjustment range of more than 40 dB.

Testing is performed under the control of the dedicated LifeTest software, which can automate such complex operations as amplifier compression tests and dynamic temperature tests. For out-of-limit conditions, the system can notify operators locally or send them an e-mail. **Maxwell Technologies, 9244 Balboa Ave., San Diego, CA 92123; (858) 503-3300, FAX: (858) 503-3344, Internet: www.maxwell.com.**

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S3W2	S3W5	N3W5	3	±0.40
S4W2	S4W5	N4W5	4	±0.40
S5W2	S5W5	N5W5	5	±0.40
S6W2	S6W5	N6W5	6	±0.40
S7W2	S7W5	N7W5	7	±0.60
S8W2	S8W5	N8W5	8	±0.60
S9W2	S9W5	N9W5	9	±0.60
S10W2	S10W5	N10W5	10	±0.60
S12W2	S12W5	N12W5	12	±0.60
S15W2	S15W5	N15W5	15	±0.60
S20W2	S20W5	N20W5	20	±0.60
S30W2	S30W5	N30W5	30	±0.85
S40W2	S40W5	N40W5	40	±0.85

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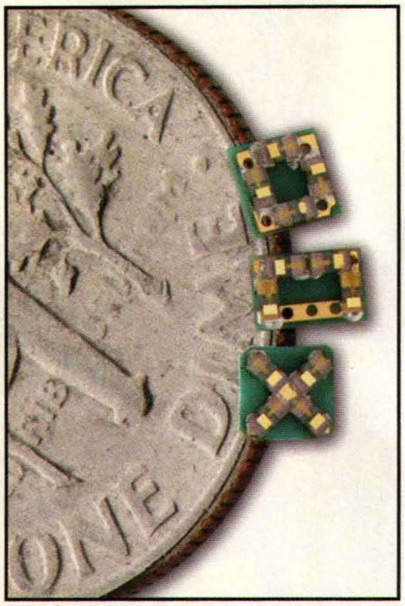
silicon antenna switches



SPECIFICATIONS

Bandwidth:
100MHz – 6GHz
Isolation:
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2400 MHz (PCS): 30 dB (typ.)
5600 MHz (WLAN): 20 dB (typ.)
Insertion loss:
900 MHz (LMDS): 0.25 dB (typ.)
2400 MHz (PCS): 0.5 dB (typ.)
5600 MHz (WLAN): 1.0 dB (typ.)
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Third order IP:
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Switching speed:
10 nS (typ.)
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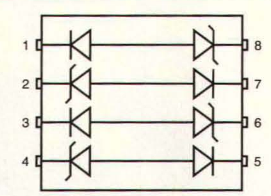

Schematic

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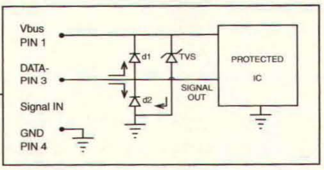

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Miniature PLL Module Locks 1500 To 1600 MHz

Leveraging chip-scale-packaging technology, this tiny PLL features a loop bandwidth of 1.25 kHz with low phase noise and minimal spurious content.

PETER STAVENICK
Managing Editor

Frequency stability is essential to most wireless designs, and the latest PLL from Z-Communications (San Diego, CA) offers a way to achieve good stability in a small package. The model PCA1550A measures only 0.50 × 0.50 × 0.14 in. (1.27 × 1.27 × 0.36 cm), yet it provides full-sized performance from 1500 to 1600 MHz. This PLL is one of the first in a series of miniature PLL modules that the company will offer in its cPLL packaging.

Suitable for MMDS and fixed broadband wireless applications as well as satellite-communication systems, the PLL uses advanced semiconductor chip-scale-packaging technology along with "0201" size components. It covers frequencies ranging from 1500 to 1600 MHz, with a 1000-kHz step size.

Integrating a phase detector, a loop filter, and a VCO, the PLL features a loop bandwidth of approximately 1.25 kHz, close-in phase-noise performance of 278 dBc/Hz and 2103 dBc/Hz at 10-kHz offset, or equivalently, an RMS phase error consisting of less than 1 deg. integrated over the 100-Hz-to-100-kHz range. The PCA 1550A also provides a maximum startup lock time of 3 ms and an adjacent-channel switching speed of 2 ms, while delivering 1.5-dBm output power with ±2.5-dB flatness into a 50-Ω load. Typical power output is efficient relative to frequency. At 25°C and at 1511 MHz, power output is slightly above +3 dBm, while at 1588 MHz, the power output is maintained at +2 dBm.

With its small housing, the PLL's harmonic suppression is −20 dBc, while the sideband reference spurs are attenuated at greater than −70 dBc. The PCA1550A PLL does not sacrifice performance due to its small size, but instead saves more space on a PCB.

The PLL sustains extensive battery life in drawing 37-mA current from a +5-VDC supply as it operates over the −40 to 85°C temperature range. By using the ADF4113 frequency synthesizer from Analog Devices (Wilmington, MA), the PLL is capable of handling a reference-oscillator input signal from 5 to 100 MHz. Also, ideal performance is optimized with a charge-pump output current of 1.25 mA.

The PCA1550A and the series to follow are suitable for automated surface-mount assembly and reflow soldering. P&A: $39.00 each; stock to 6 wks. (tape-and-reel format). **Z-Communications, Inc., 9939 Via Pasar, San Diego, CA 92126; (858) 621-2700, FAX: (858) 621-2722, e-mail: applications@zcomm.com, Internet: www.zcomm.com.**

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Software Speeds Cell-Site Surveys

This flexible software package can simplify the selection of cell sites and calculation of line-of-sight distances when installing point-to-point radio systems.

JACK BROWNE
Publisher/Editor

Installing cellular towers and other radio-infrastructure equipment requires careful planning and painstaking measurements. One of the tools that site planners now have at their disposal to simplify the task is the Terrain Navigator 2001 Windows-based software from Maptech (Amesbury, MA). This powerful program works with data from United States Geological Survey (USGS) topographic maps, allowing operators to view locations in 2D or 3D and find exact coordinates for accurately selecting optimum cell-site locations and for planning radio-link installations.

Terrain Navigator 2001 can be ordered with as many topographic maps as needed for an application. A total of 30 "Super Regions" are available, with up to 3500 USGS topographic maps per Super Region collection.

Operators have a variety of tools at their disposal for setting markers, linking to a GPS Rx, changing screen views, and printing customized maps. Using the "Go To" menu selection allows an operator to find a location by coordinates, by entering a zip code or the name of a town or city, entering a name, or using a reference code. The "Mode" menu selection allows the operator to choose from a number of different views, including 2D and 3D views. Both views can be shown simultaneously for an area of interest using a "seamless" split-screen view.

Navigating around a map is simple, using the variety of tools that includes a compass tool, a centering tool, a drag tool, and by clicking on edge arrows to move the map in a selected direction.

For system installers, however, the real power in Terrain Navigator 2001 is the capability to place markers on precise locations, define tracks and routes, and plot distances between points in 3D. Straight-line and free-hand distance measuring tools allow operators to quickly calculate the distance between two or more points. By using the software's profile feature, a cross-sectional model can be created to study the elevation changes along a particular route. A line-of-sight calculator shows any obstructions along a path.

Terrain Navigator 2001 also works with a GPS Rx connected to a computer's serial communication port, allowing data to be transferred in either direction. The software is designed for use with Windows 95, 98, 2000, ME, or NT running on a Pentium computer. **Maptech, 10 Industrial Way, Amesbury, MA 01913; (888) 839-5551, (978) 792-1000, Internet: www.maptech.com.** MRF

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Universal Modulator Spans 2 To 18 GHz

This compact assembly blends switches, bandpass filters, a digital attenuator, and a digitally controlled I/Q modulator for accurate control of signal phase and amplitude.

JACK BROWNE
Publisher/Editor

Vector modulators provide the control of signal phase and amplitude needed for information transfer in complex communications systems. For wideband military applications requiring full coverage of the 2-to-18-GHz range, there may be no better vector-modulator solution than the model SA-69-BD universal coherent modulator subassembly from G.T. Microwave, Inc. (Randolph, NJ). It combines several stages of amplification, a high-speed vector modulator, wide-dynamic-range attenuation, and a digitally controlled switched-filter bank to provide modulated signals from 2 to 18 GHz with good amplitude and phase accuracy.

The model SA-69-BD universal coherent modulator subassembly accepts maximum input levels to +20 dBm. Signals are processed through an I/Q vector modulator with separate 12-b digital control of phase and amplitude. The phase flatness versus frequency (from 2 to 18 GHz) is at least ±20 deg., while the amplitude flatness versus frequency is at least ±3.5 dB. The modulator achieves at least 18-dB isolation between ports and boasts 500-ns switching speed.

From the vector modulator, signals are amplified and then passed through a wideband 2-to-18-GHz attenuator with 80-dB dynamic range and 0.08-dB attenuation resolution. The 10-b digital attenuator, which also features 500-ns switching speed, achieves ±4.5-dB attenuation flatness across the full frequency range.

Output signals from the attenuator are amplified and then switched among four bandpass filters. The filters pass bands of 2.0 to 3.5 GHz, 3.5 to 6.0 GHz, 6.0 to 10.4 GHz, and 10.4 to 18.0 GHz with out-of-band rejection as good as 55 dB. A switch at the output of the filters selects the band of interest. The switching speed for the input switch is 200 ns, while the switching speed for the output switch is 300 ns, or a worst-case total of 500 ns.

Overall, the modulator assembly offers ±20-deg. phase flatness versus frequency. It features 22-dB gain from 2 to 18 GHz with +14-dBm minimum output power at 1-dB compression. AM sidebands are down –65 dBc to the megahertz of a signal, while overall amplitude flatness is ±3.5 dB. Harmonics are –60 dBc and the overall assembly noise figure is 14 dB. The TTL-compatible SA-69-BD measures 4.25 × 9.0 × 2.0 in. (10.80 × 22.86 × 5.08 cm) with SMA female connectors. **G.T. Microwave, Inc., 2 Emery Ave., Randolph, NJ 07869; (973) 361-5700,** FAX: (973) 361-5722, e-mail: gtmicrowav@aol.com, **Internet: www.GTmicrowave.com.**

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ABLE TO DIRECTLY interface to fiber-optic photodiodes, the AD8304 logarithmic converter delivers 160-dB dynamic range and 0.1-dB accuracy. It overcomes the expense that is associated with hybrids and the calibration complexities associated with switched-gain transimpedance-amplifier solutions. Operating from a single +5-VDC supply, the DC output provides a log-scaled representation of the input current. P&A: $19.80 (1000 qty.).

Analog Devices, Inc., 831 Woburn St., Wilmington, MA 01887; (781) 937-1428, FAX: (781) 821-4273, Internet: www.analog.com.

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Antenna Switches Handle 5 To 6 GHz

THE MNM4200™ SERIES of surface-mount silicon (Si) antenna switches meets the requirements of 802.11a and HiperLAN2 broadband wireless local-area-network (WLAN) applications. The series offers configurations to emulate transfer; diversity; transmit/receive; and single-pole, double-throw (SPDT) switching functions and to meet WLAN application requirements from 5 to 6 GHz.

Microsemi Corp., 2381 Morse Ave., Irvine, CA 92614; (800) 713-4113, FAX: (949) 756-0308, Internet: www.microsemi.com.

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Switches Target Bluetooth

A LINE OF four single-pole, double-throw (SPDT) reflective switches suits wireless local-area-network (WLAN), Bluetooth products, code-division-multiple-access (CDMA), time-division-multiple-access (TDMA), Global System for Mobile Communications (GSM), and wide-band-CDMA (WCDMA) applications. Models HWS301 and HWS303 are low-power SPDT switches that offer 0.4-dB insertion loss and 23-dB isolation at 2.5 GHz. General-purpose SPDT switch models HWS311 and HWS314 support 0.5-dB insertion loss and 23-dB isolation at 2.5 GHz. Model HWS332 is an integrated-circuit (IC) field-effect-transistor (FET) SPDT switch featuring 42-dB isolation at 1 GHz and 33-dB isolation at 2 GHz, with an insertion loss of 0.5 dB at 1 GHz.

Hexawave, 1F, 2 Prosperity Rd., Science-Based Industrial Park, Hsinchu, Taiwan, R.O.C.; 886-3-5785100, FAX: 886-3-5770512.

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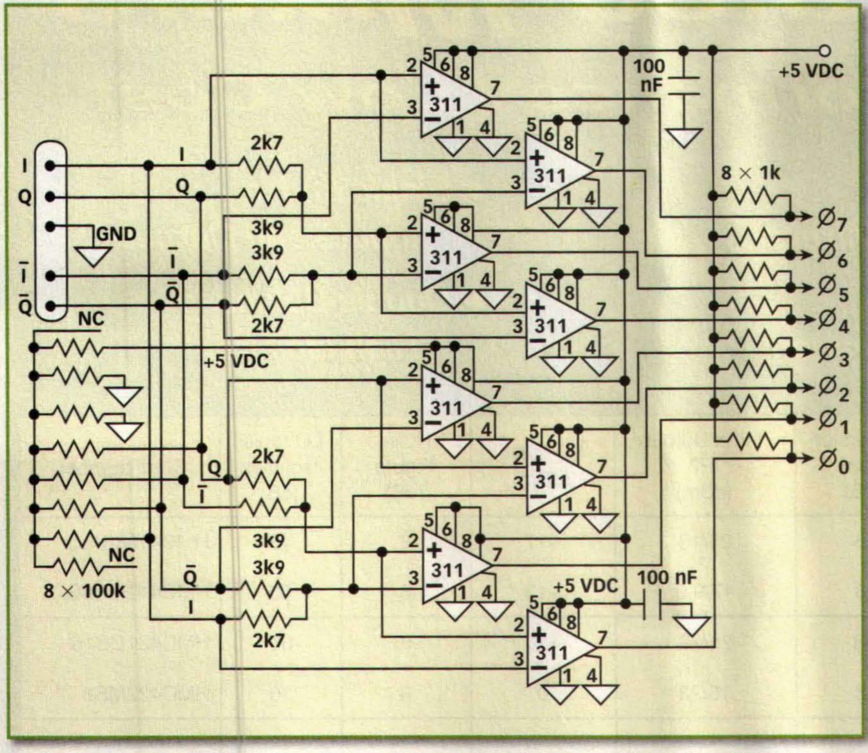

4. This is the circuit diagram of the 8-channel, limiting IF amplifier described theoretically in Fig. 3.

(Continued from page 112)

ages of the LM311 comparators used as limiting IF amplifiers. Using better components and/or AC-coupled limiting amplifiers should further improve this figure. The new IF strip and demodulator improved the overall Rx performance, since several gain stages with AGC could be removed. The latter actually added distortion and noise to the signal, so that the new IF strip and demodulator actually improved the Rx sensitivity by approximately 1 dB.

In addition, since digital switching transients are completely removed by D-flip-flops, the new demodulator supports higher clock frequencies and, thus, larger RF carrier offsets between the Tx and the Rx. MRF

REFERENCES

1. A. Mashhour, W. Domino, and N. Beamish: "On the Direct Conversion Receiver—A Tutorial," *Microwave Journal*, Vol. 44, No. 6, June 2001, pp. 114-128.

2. Matjaz Vidmar: "Achieve Phasor Rotation With Analog Switches," Microwaves & RF, Vol. 39, No. 2, February 2000, pp. 59-64.

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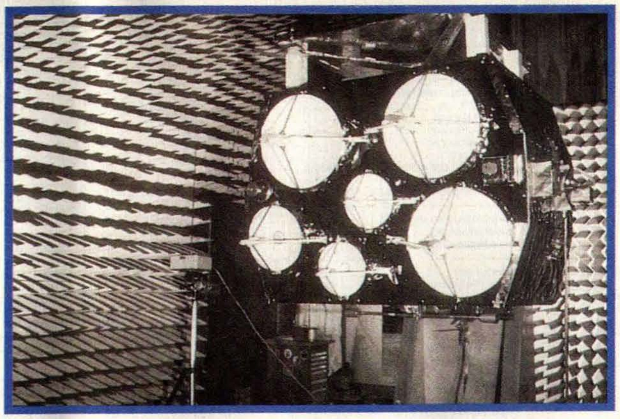
looking back



APPROXIMATELY 17 YEARS AGO, a news story on compact-antenna test ranges pointed to the need for improved measurement capabilities to meet the needs of growing satellite-communications applications.

next month

Microwaves & RF March Editorial Preview

Issue Theme: Wireless Technology

News

Wireless applications paved the way for tremendous growth in the high-frequency industry during the 1990s. But business slowed during 2000 and throughout 2001, leading to plant shutdowns and layoffs. The beginning of the strong wireless run coincided with the first Wireless Symposium & Exhibition in 1993. The show is now known as Wireless Systems 2002 and is entering its 10th year. What can be learned from the climate of the show? Will it mark the start of better times? The March issue will offer some of highlights of this 10th wireless show, along with insights from interviews with attendees and exhibitors on the future of wireless business and technology.

Design Features

March features an examination by authors from Analog Devices (Wilmington, MA) into the need for precise gain control in wireless systems. Additional technical articles include Part 4 in a multipart series on the design of short-range, low-power radio systems and a review of the techniques and equipment needed to perform RF measurements on Bluetooth components and systems. In addition, an article on 5-GHz WLAN systems will explore how to manipulate complex OFDM signals.

Product Technology

The March Product Technology section will cover the launch of a new form of high-frequency oscillator. Based on crystal-oscillator technology, but with the stability associated with a Rb atomic-frequency standard. One of the keys to its performance is the innovative use of digital technology. Additional articles will explore a new line of high-efficiency cellular-band amplifiers from a supplier that is normally associated with computers, a low-cost spectrum-analyzer attachment for an oscilloscope, a line of V-band components for wideband, license-free communications at 60 GHz, and a series of high-Q ceramic filters.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♥ Constant phase with △ attenuation.
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